

**p**

$$I(J^P) = \frac{1}{2}(\frac{1}{2}^+) \text{ Status: } ***$$

### **p MASS (atomic mass units u)**

The mass is known much more precisely in u (atomic mass units) than in MeV. See the next data block.

VALUE (u)	DOCUMENT ID	TECN	COMMENT
<b>1.007276466812±0.000000000090</b>	MOHR	12	RVUE 2010 CODATA value
• • • We do not use the following data for averages, fits, limits, etc. • • •			
1.00727646677 ± 0.00000000010	MOHR	08	RVUE 2006 CODATA value
1.00727646688 ± 0.00000000013	MOHR	05	RVUE 2002 CODATA value
1.00727646688 ± 0.00000000013	MOHR	99	RVUE 1998 CODATA value
1.007276470 ± 0.000000012	COHEN	87	RVUE 1986 CODATA value

NODE=S016AMU

NODE=S016AMU

NODE=S016AMU

### **p MASS (MeV)**

The mass is known much more precisely in u (atomic mass units) than in MeV. The conversion from u to MeV,  $1 \text{ u} = 931.494\ 061(21) \text{ MeV}/c^2$  (MOHR 12, the 2010 CODATA value), involves the relatively poorly known electronic charge.

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
<b>938.272046±0.000021</b>	MOHR	12	RVUE 2010 CODATA value
• • • We do not use the following data for averages, fits, limits, etc. • • •			
938.272013±0.000023	MOHR	08	RVUE 2006 CODATA value
938.272029±0.000080	MOHR	05	RVUE 2002 CODATA value
938.271998±0.000038	MOHR	99	RVUE 1998 CODATA value
938.27231 ± 0.00028	COHEN	87	RVUE 1986 CODATA value
938.2796 ± 0.0027	COHEN	73	RVUE 1973 CODATA value

NODE=S016M

NODE=S016M

NODE=S016M

### **| $m_p - m_{\bar{p}}|/m_p$**

A test of *CPT* invariance. Note that the comparison of the  $\bar{p}$  and  $p$  charge-to-mass ratio, given in the next data block, is much better determined.

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt;2 × 10<sup>-9</sup></b>	90	<sup>1</sup> HORI	06	SPEC $\bar{p}e^-$ He atom
• • • We do not use the following data for averages, fits, limits, etc. • • •				
<1.0 × 10 <sup>-8</sup>	90	<sup>1</sup> HORI	03	SPEC $\bar{p}e^-$ <sup>4</sup> He, $\bar{p}e^-$ <sup>3</sup> He
<6 × 10 <sup>-8</sup>	90	<sup>1</sup> HORI	01	SPEC $\bar{p}e^-$ He atom
<5 × 10 <sup>-7</sup>		<sup>2</sup> TORII	99	SPEC $\bar{p}e^-$ He atom

NODE=S016DM

NODE=S016DM

NODE=S016DM

NODE=S016DM;LINKAGE=C

NODE=S016DM;LINKAGE=B

### **$\bar{p}/p$ CHARGE-TO-MASS RATIO, $|\frac{q_{\bar{p}}}{m_{\bar{p}}}| / (\frac{q_p}{m_p})$**

A test of *CPT* invariance. Listed here are measurements involving the *inertial* masses. For a discussion of what may be inferred about the ratio of  $\bar{p}$  and  $p$  *gravitational* masses, see ERICSON 90; they obtain an upper bound of  $10^{-6}$ – $10^{-7}$  for violation of the equivalence principle for  $\bar{p}$ 's.

VALUE	DOCUMENT ID	TECN	COMMENT
<b>0.9999999991±0.0000000009</b>	GABRIELSE	99	TRAP Penning trap
• • • We do not use the following data for averages, fits, limits, etc. • • •			
1.0000000015 ± 0.0000000011	<sup>3</sup> GABRIELSE	95	TRAP Penning trap
1.000000023 ± 0.000000042	<sup>4</sup> GABRIELSE	90	TRAP Penning trap

NODE=S016CMR

NODE=S016CMR

NODE=S016CMR

<sup>3</sup>Equation (2) of GABRIELSE 95 should read  $M(\bar{p})/M(p) = 0.999\ 999\ 9985$  (11) (G. Gabrielse, private communication).

<sup>4</sup>GABRIELSE 90 also measures  $m_{\bar{p}}/m_{e^-} = 1836.152660 \pm 0.000083$  and  $m_p/m_{e^-} = 1836.152680 \pm 0.000088$ . Both are completely consistent with the 1986 CODATA (COHEN 87) value for  $m_p/m_{e^-}$  of  $1836.152701 \pm 0.000037$ .

$$(|\frac{q_p}{m_p}| - |\frac{q_{\bar{p}}}{m_{\bar{p}}}|) / \frac{q_p}{m_p}$$

A test of *CPT* invariance. Taken from the  $\bar{p}/p$  charge-to-mass ratio, above.

VALUE	DOCUMENT ID
<b>(<math>-9 \pm 9</math>) <math>\times 10^{-11}</math> OUR EVALUATION</b>	

$$|q_p + q_{\bar{p}}|/e$$

A test of *CPT* invariance. Note that the comparison of the  $\bar{p}$  and  $p$  charge-to-mass ratios given above is much better determined. See also a similar test involving the electron.

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$<2 \times 10^{-9}$	90	5 HORI	06	SPEC $\bar{p}e^-$ -He atom
<b>• • • We do not use the following data for averages, fits, limits, etc. • • •</b>				
$<1.0 \times 10^{-8}$	90	5 HORI	03	SPEC $\bar{p}e^-$ ${}^4\text{He}$ , $\bar{p}e^-$ ${}^3\text{He}$
$<6 \times 10^{-8}$	90	5 HORI	01	SPEC $\bar{p}e^-$ -He atom
$<5 \times 10^{-7}$		6 TORII	99	SPEC $\bar{p}e^-$ -He atom
$<2 \times 10^{-5}$		7 HUGHES	92	RVUE

<sup>5</sup>HORI 01, HORI 03, and HORI 06 use the more-precisely-known constraint on the  $\bar{p}$  charge-to-mass ratio of GABRIELSE 99 (see above) to get their results. Their results are not independent of the HORI 01, HORI 03, and HORI 06 values for  $|m_p - m_{\bar{p}}|/m_p$ , above.

<sup>6</sup>TORII 99 uses the more-precisely-known constraint on the  $\bar{p}$  charge-to-mass ratio of GABRIELSE 95 (see above) to get this result. This is not independent of the TORII 99 value for  $|m_p - m_{\bar{p}}|/m_p$ , above.

<sup>7</sup>HUGHES 92 uses recent measurements of Rydberg-energy and cyclotron-frequency ratios.

$$|q_p + q_e|/e$$

See BRESSI 11 for a summary of experiments on the neutrality of matter.  
See also "n CHARGE" in the neutron Listings.

VALUE	DOCUMENT ID	COMMENT
$<1 \times 10^{-21}$	8 BRESSI	11 Neutrality of SF <sub>6</sub>
<b>• • • We do not use the following data for averages, fits, limits, etc. • • •</b>		
$<3.2 \times 10^{-20}$	9 SENGUPTA	00 binary pulsar
$<0.8 \times 10^{-21}$	MARINELLI	84 Magnetic levitation
$<1.0 \times 10^{-21}$	8 DYLLA	73 Neutrality of SF <sub>6</sub>

<sup>8</sup>BRESSI 11 uses the method of DYLLA 73 but finds serious errors in that experiment that greatly reduce its accuracy. The BRESSI 11 limit assumes that  $n \rightarrow pe^- \nu_e$  conserves charge. Thus the limit applies equally to the charge of the neutron.

<sup>9</sup>SENGUPTA 00 uses the difference between the observed rate of rotational energy loss by the binary pulsar PSR B1913+16 and the rate predicted by general relativity to set this limit. See the paper for assumptions.

## $p$ MAGNETIC MOMENT

See the "Note on Baryon Magnetic Moments" in the  $\Lambda$  Listings.

VALUE ( $\mu_N$ )	DOCUMENT ID	TECN	COMMENT
<b>2.792847356 <math>\pm</math> 0.000000023</b>	MOHR	12	RVUE 2010 CODATA value

NODE=S016CMR;LINKAGE=B

NODE=S016CMR;LINKAGE=A

NODE=S016DMM

NODE=S016DMM

NODE=S016DMM

NODE=S016DQ2

NODE=S016DQ2

NODE=S016DQ2

NODE=S016DQ2;LINKAGE=C

NODE=S016DQ2;LINKAGE=B

NODE=S016DQ2;LINKAGE=A

NODE=S016DQ

NODE=S016DQ

NODE=S016DQ

NODE=S016DQ;LINKAGE=BR

NODE=S016DQ;LINKAGE=SE

NODE=S016MM

NODE=S016MM

NODE=S016MM

• • • We do not use the following data for averages, fits, limits, etc. • • •

2.792847356±0.000000023	MOHR	08	RVUE	2006 CODATA value
2.792847351±0.000000028	MOHR	05	RVUE	2002 CODATA value
2.792847337±0.000000029	MOHR	99	RVUE	1998 CODATA value
2.792847386±0.000000063	COHEN	87	RVUE	1986 CODATA value
2.7928456 ±0.0000011	COHEN	73	RVUE	1973 CODATA value

## ρ MAGNETIC MOMENT

A few early results have been omitted.

VALUE ( $\mu_N$ )	DOCUMENT ID	TECN	COMMENT
<b>-2.792845±0.000012 OUR AVERAGE</b>	[ $-2.793 \pm 0.006 \mu_N$ OUR 2012 AVERAGE]		
<b>-2.792845±0.000012</b>	DISCIACCA	13	TRAP Single $\bar{p}$ , Penning trap
• • • We do not use the following data for averages, fits, limits, etc. • • •			
-2.7862 ± 0.0083	PASK	09	CNTR $\bar{p}$ He <sup>+</sup> hyperfine structure
-2.8005 ± 0.0090	KREISSL	88	CNTR $\bar{p}$ <sup>208</sup> Pb 11→ 10 X-ray
-2.817 ± 0.048	ROBERTS	78	CNTR
-2.791 ± 0.021	HU	75	CNTR Exotic atoms

## ( $\mu_p + \mu_{\bar{p}}) / \mu_p$

A test of *CPT* invariance.

VALUE (units $10^{-6}$ )	DOCUMENT ID	TECN	COMMENT
<b>0±5</b>	DISCIACCA	13	TRAP Single $\bar{p}$ , Penning trap

## p ELECTRIC DIPOLE MOMENT

A nonzero value is forbidden by both *T* invariance and *P* invariance.

VALUE ( $10^{-23}$ ecm)	EVTS	DOCUMENT ID	TECN	COMMENT
< <b>0.54</b>	10	DMITRIEV	03	Uses <sup>199</sup> Hg atom EDM
• • • We do not use the following data for averages, fits, limits, etc. • • •				
- 3.7 ± 6.3		CHO	89	NMR TI F molecules
< 400		DZUBA	85	THEO Uses <sup>129</sup> Xe moment
130 ± 200	11	WILKENING	84	
900 ± 1400	12	WILKENING	84	
700 ± 900	1G	HARRISON	69	MBR Molecular beam

10 DMITRIEV 03 calculates this limit from the limit on the electric dipole moment of the <sup>199</sup>Hg atom.

11 This WILKENING 84 value includes a finite-size effect and a magnetic effect.

12 This WILKENING 84 value is more cautious than the other and excludes the finite-size effect, which relies on uncertain nuclear integrals.

## p ELECTRIC POLARIZABILITY $\alpha_p$

For a very complete review of the “polarizability of the nucleon and Compton scattering,” see SCHUMACHER 05. His recommended values for the proton are  $\alpha_p = (12.0 \pm 0.6) \times 10^{-4} \text{ fm}^3$  and  $\beta_p = (1.9 \mp 0.6) \times 10^{-4} \text{ fm}^3$ , almost exactly our averages.

VALUE ( $10^{-4} \text{ fm}^3$ )	DOCUMENT ID	TECN	COMMENT
<b>11.2 ±0.4 OUR AVERAGE</b>			
[( $12.0 \pm 0.6) \times 10^{-4} \text{ fm}^3$ OUR 2012 AVERAGE]			
10.65±0.35±0.36	MCGOVERN	13	RVUE $\chi$ EFT + Compton scattering
12.1 ±1.1 ±0.5	13 BEANE	03	EFT + $\gamma p$
11.82±0.98 <sup>+0.52</sup> <sub>-0.98</sub>	14 BLANPIED	01	LEGS $p(\vec{\gamma},\gamma)$ , $p(\vec{\gamma},\pi^0)$ , $p(\vec{\gamma},\pi^+)$
11.9 ±0.5 ±1.3	15 OLMSDEL...	01	CNTR $\gamma p$ Compton scattering
12.1 ±0.8 ±0.5	16 MACGIBBON	95	RVUE global average

NODE=S016MM1

NODE=S016MM1

NODE=S016MM1

NEW

NODE=S016MMD

NODE=S016MMD

NODE=S016MMD

NODE=S016EDM

NODE=S016EDM

NODE=S016EDM

OCCUR=2

NODE=S016EDM;LINKAGE=DM

NODE=S016EDM;LINKAGE=A

NODE=S016EDM;LINKAGE=B

NODE=S016EPL

NODE=S016EPL

NODE=S016EPL

NEW

OCCUR=2

• • • We do not use the following data for averages, fits, limits, etc. • • •

11.7 $\pm 0.8$ $\pm 0.7$	17 BARANOV 01 RVUE Global average
12.5 $\pm 0.6$ $\pm 0.9$	MACGIBBON 95 CNTR $\gamma p$ Compton scattering
9.8 $\pm 0.4$ $\pm 1.1$	HALLIN 93 CNTR $\gamma p$ Compton scattering
10.62 <sup>+1.25</sup> <sub>-1.19</sub> <sup>+1.07</sup> <sub>-1.03</sub>	ZIEGER 92 CNTR $\gamma p$ Compton scattering
10.9 $\pm 2.2$ $\pm 1.3$	18 FEDERSPIEL 91 CNTR $\gamma p$ Compton scattering

13 BEANE 03 uses effective field theory and low-energy  $\gamma p$  and  $\gamma d$  Compton-scattering data. It also gets for the isoscalar polarizabilities (see the erratum)  $\alpha_N = (13.0 \pm 1.9^{+3.9}_{-1.5}) \times 10^{-4} \text{ fm}^3$  and  $\beta_N = (-1.8 \pm 1.9^{+2.1}_{-0.9}) \times 10^{-4} \text{ fm}^3$ .

14 BLANPIED 01 gives  $\alpha_p + \beta_p$  and  $\alpha_p - \beta_p$ . The separate  $\alpha_p$  and  $\beta_p$  are provided to us by A. Sandorfi. The first error above is statistics plus systematics; the second is from the model.

15 This OLMOSDELEON 01 result uses the TAPS data alone, and does not use the (re-evaluated) sum-rule constraint that  $\alpha + \beta = (13.8 \pm 0.4) \times 10^{-4} \text{ fm}^3$ . See the paper for a discussion.

16 MACGIBBON 95 combine the results of ZIEGER 92, FEDERSPIEL 91, and their own experiment to get a “global average” in which model errors and systematic errors are treated in a consistent way. See MACGIBBON 95 for a discussion.

17 BARANOV 01 combines the results of 10 experiments from 1958 through 1995 to get a global average that takes into account both systematic and model errors and does not use the theoretical constraint on the sum  $\alpha_p + \beta_p$ .

18 FEDERSPIEL 91 obtains for the (static) electric polarizability  $\alpha_p$ , defined in terms of the induced electric dipole moment by  $D = 4\pi\epsilon_0\alpha_p E$ , the value  $(7.0 \pm 2.2 \pm 1.3) \times 10^{-4} \text{ fm}^3$ .

### $p$ MAGNETIC POLARIZABILITY $\beta_p$

The electric and magnetic polarizabilities are subject to a dispersion sum-rule constraint  $\bar{\alpha} + \bar{\beta} = (14.2 \pm 0.5) \times 10^{-4} \text{ fm}^3$ . Errors here are anticorrelated with those on  $\bar{\alpha}_p$  due to this constraint.

VALUE ( $10^{-4} \text{ fm}^3$ )	DOCUMENT ID	TECN	COMMENT
<b>2.5 <math>\pm 0.4</math> OUR AVERAGE</b>	OUR 2012 AVERAGE]		Error includes scale factor of 1.2. $[(1.9 \pm 0.5) \times 10^{-4} \text{ fm}^3$
3.15 $\pm 0.35$ <sub>0.36</sub>	MCGOVERN 13 RVUE	$\chi$ EFT + Compton scattering	
3.4 $\pm 1.1$ $\pm 0.1$	19 BEANE 03	EFT + $\gamma p$	
1.43 $\pm 0.98$ <sub>0.98</sub> <sup>+0.52</sup>	20 BLANPIED 01 LEGS	$p(\vec{\gamma},\gamma)$ , $p(\vec{\gamma},\pi^0)$ , $p(\vec{\gamma},\pi^+)$	
1.2 $\pm 0.7$ $\pm 0.5$	21 OLMOSDEL... 01 CNTR	$\gamma p$ Compton scattering	
2.1 $\pm 0.8$ $\pm 0.5$	22 MACGIBBON 95 RVUE	global average	

• • • We do not use the following data for averages, fits, limits, etc. • • •

2.3 $\pm 0.9$ $\pm 0.7$	23 BARANOV 01 RVUE Global average
1.7 $\pm 0.6$ $\pm 0.9$	MACGIBBON 95 CNTR $\gamma p$ Compton scattering
4.4 $\pm 0.4$ $\pm 1.1$	HALLIN 93 CNTR $\gamma p$ Compton scattering
3.58 <sup>+1.19</sup> <sub>-1.25</sub> <sup>+1.03</sup> <sub>-1.07</sub>	ZIEGER 92 CNTR $\gamma p$ Compton scattering
3.3 $\pm 2.2$ $\pm 1.3$	FEDERSPIEL 91 CNTR $\gamma p$ Compton scattering

19 BEANE 03 uses effective field theory and low-energy  $\gamma p$  and  $\gamma d$  Compton-scattering data. It also gets for the isoscalar polarizabilities (see the erratum)  $\alpha_N = (13.0 \pm 1.9^{+3.9}_{-1.5}) \times 10^{-4} \text{ fm}^3$  and  $\beta_N = (-1.8 \pm 1.9^{+2.1}_{-0.9}) \times 10^{-4} \text{ fm}^3$ .

20 BLANPIED 01 gives  $\alpha_p + \beta_p$  and  $\alpha_p - \beta_p$ . The separate  $\alpha_p$  and  $\beta_p$  are provided to us by A. Sandorfi. The first error above is statistics plus systematics; the second is from the model.

21 This OLMOSDELEON 01 result uses the TAPS data alone, and does not use the (re-evaluated) sum-rule constraint that  $\alpha + \beta = (13.8 \pm 0.4) \times 10^{-4} \text{ fm}^3$ . See the paper for a discussion.

22 MACGIBBON 95 combine the results of ZIEGER 92, FEDERSPIEL 91, and their own experiment to get a “global average” in which model errors and systematic errors are treated in a consistent way. See MACGIBBON 95 for a discussion.

23 BARANOV 01 combines the results of 10 experiments from 1958 through 1995 to get a global average that takes into account both systematic and model errors and does not use the theoretical constraint on the sum  $\alpha_p + \beta_p$ .

NODE=S016EPL;LINKAGE=B3

NODE=S016EPL;LINKAGE=SF

NODE=S016EPL;LINKAGE=OD

NODE=S016EPL;LINKAGE=MG

NODE=S016EPL;LINKAGE=BV

NODE=S016EPL;LINKAGE=A

NODE=S016MPL

NODE=S016MPL

NODE=S016MPL

NEW

OCCUR=2

NODE=S016MPL;LINKAGE=B3

NODE=S016MPL;LINKAGE=SF

NODE=S016MPL;LINKAGE=OD

NODE=S016MPL;LINKAGE=MG

NODE=S016MPL;LINKAGE=BV

## $p$ CHARGE RADIUS

This is the rms electric charge radius,  $\sqrt{\langle r_E^2 \rangle}$ .

Most measurements of the radius of the proton involve electron-proton interactions, and most of the more recent values agree with one another. The most precise of these is  $r_p = 0.879(8)$  fm (BERNAUER 10). The CODATA 10 value (MOHR 12), obtained from the electronic results, is 0.8775(51). However, a measurement using muonic hydrogen finds  $r_p = 0.84087(39)$  fm (ANTOGNINI 13), which is 13 times more precise and seven standard deviations (using the CODATA 10 error) from the electronic results.

Since POHL 10 (the first  $\mu p$  result), there has been a lot of discussion about the disagreement, especially concerning the modeling of muonic hydrogen. Here is an incomplete list of papers: DERUJULA 10, CLOET 11, DISTLER 11, DERUJULA 11, ARRINGTON 11, BERNAUER 11, and HILL 11.

Until the difference between the  $e p$  and  $\mu p$  values is understood, it does not make sense to average the values together. For the present, we give both values. It is up to workers in this field to solve this puzzle.

VALUE (fm)	DOCUMENT ID	TECN	COMMENT
<b>0.84087±0.00026±0.00029</b>	ANTOGNINI	13	LASR $\mu p$ -atom Lamb shift
<b>0.8775 ± 0.0051</b>	MOHR	12	RVUE 2010 CODATA, $e p$ data
<b>• • • We do not use the following data for averages, fits, limits, etc. • • •</b>			
0.879 ± 0.005 ± 0.006	BERNAUER	10	SPEC $e p \rightarrow e p$ form factor
0.912 ± 0.009 ± 0.007	BORISYUK	10	reanalyzes old $e p$ data
0.871 ± 0.009 ± 0.003	HILL	10	$z$ -expansion reanalysis
0.84184 ± 0.00036 ± 0.00056	POHL	10	LASR See ANTOGNINI 13
0.8768 ± 0.0069	MOHR	08	RVUE 2006 CODATA value
0.844 +0.008 -0.004	BELUSHKIN	07	Dispersion analysis
0.897 ± 0.018	BLUNDEN	05	SICK 03 + $2\gamma$ correction
0.8750 ± 0.0068	MOHR	05	RVUE 2002 CODATA value
0.895 ± 0.010 ± 0.013	SICK	03	$e p \rightarrow e p$ reanalysis
0.830 ± 0.040 ± 0.040	24 ESCHRICHH	01	$e p \rightarrow e p$
0.883 ± 0.014	MELNIKOV	00	1S Lamb Shift in H
0.880 ± 0.015	ROSENFELDR.00		$e p +$ Coul. corrections
0.847 ± 0.008	MERGELL	96	$e p +$ disp. relations
0.877 ± 0.024	WONG	94	reanalysis of Mainz $e p$ data
0.865 ± 0.020	MCCORD	91	$e p \rightarrow e p$
0.862 ± 0.012	SIMON	80	$e p \rightarrow e p$
0.880 ± 0.030	BORKOWSKI	74	$e p \rightarrow e p$
0.810 ± 0.020	AKIMOV	72	$e p \rightarrow e p$
0.800 ± 0.025	FREREJACQ...	66	$e p \rightarrow e p$ ( $CH_2$ tgt.)
0.805 ± 0.011	HAND	63	$e p \rightarrow e p$

24 ESCHRICHH 01 actually gives  $\langle r^2 \rangle = (0.69 \pm 0.06 \pm 0.06) \text{ fm}^2$ .

NODE=S016CR

## $p$ MAGNETIC RADIUS

This is the rms magnetic radius,  $\sqrt{\langle r_M^2 \rangle}$ .

VALUE (fm)	DOCUMENT ID	TECN	COMMENT
<b>0.777±0.013±0.010</b>	BERNAUER	10	SPEC $e p \rightarrow e p$ form factor
<b>• • • We do not use the following data for averages, fits, limits, etc. • • •</b>			
0.876 ± 0.010 ± 0.016	BORISYUK	10	reanalyzes old $e p \rightarrow e p$ data
0.854 ± 0.005	BELUSHKIN	07	Dispersion analysis

NODE=S016CR;LINKAGE=ES

NODE=S016MCR

NODE=S016MCR  
NODE=S016MCR

## $p$ MEAN LIFE

A test of baryon conservation. See the “ $p$  Partial Mean Lives” section below for limits for identified final states. The limits here are to “anything” or are for “disappearance” modes of a bound proton ( $p$ ) or ( $n$ ). See also the  $3\nu$  modes in the “Partial Mean Lives” section. Table 1 of BACK 03 is a nice summary.

LIMIT (years)	PARTICLE	CL%	DOCUMENT ID	TECN	COMMENT
<b>&gt;5.8 × 10<sup>29</sup></b>	<b><math>n</math></b>	90	25 ARAKI	06	KLND $n \rightarrow$ invisible
<b>&gt;2.1 × 10<sup>29</sup></b>	<b><math>p</math></b>	90	26 AHMED	04	SNO $p \rightarrow$ invisible

NODE=S016215

NODE=S016T

NODE=S016T

• • • We do not use the following data for averages, fits, limits, etc. • • •

$>1.9 \times 10^{29}$	<i>n</i>	90	26 AHMED	04 SNO	<i>n</i> → invisible	OCCUR=2
$>1.8 \times 10^{25}$	<i>n</i>	90	27 BACK	03 BORX		OCCUR=2
$>1.1 \times 10^{26}$	<i>p</i>	90	27 BACK	03 BORX		
$>3.5 \times 10^{28}$	<i>p</i>	90	28 ZDESENKO	03	<i>p</i> → invisible	
$>1 \times 10^{28}$	<i>p</i>	90	29 AHMAD	02 SNO	<i>p</i> → invisible	
$>4 \times 10^{23}$	<i>p</i>	95	TRETYAK	01	<i>d</i> → <i>n</i> + ?	
$>1.9 \times 10^{24}$	<i>p</i>	90	30 BERNABEI	00B DAMA		
$>1.6 \times 10^{25}$	<i>p, n</i>		31,32 EVANS	77		
$>3 \times 10^{23}$	<i>p</i>		32 DIX	70 CNTR		
$>3 \times 10^{23}$	<i>p, n</i>		32,33 FLEROV	58		

25 ARAKI 06 looks for signs of de-excitation of the residual nucleus after disappearance of a neutron from the *s* shell of  $^{12}\text{C}$ .

26 AHMED 04 looks for  $\gamma$  rays from the de-excitation of a residual  $^{15}\text{O}^*$  or  $^{15}\text{N}^*$  following the disappearance of a neutron or proton in  $^{16}\text{O}$ .

27 BACK 03 looks for decays of unstable nuclides left after *N* decays of parent  $^{12}\text{C}$ ,  $^{13}\text{C}$ ,  $^{16}\text{O}$  nuclei. These are “invisible channel” limits.

28 ZDESENKO 03 gets this limit on proton disappearance in deuterium by analyzing SNO data in AHMAD 02.

29 AHMAD 02 (see its footnote 7) looks for neutrons left behind after the disappearance of the proton in deuterons.

30 BERNABEI 00B looks for the decay of a  $^{128}\text{I}$  nucleus following the disappearance of a proton in the otherwise-stable  $^{53}\text{Xe}$  nucleus.

31 EVANS 77 looks for the daughter nuclide  $^{129}\text{Xe}$  from possible  $^{130}\text{Te}$  decays in ancient Te ore samples.

32 This mean-life limit has been obtained from a half-life limit by dividing the latter by  $\ln(2) = 0.693$ .

33 FLEROV 58 looks for the spontaneous fission of a  $^{232}\text{Th}$  nucleus after the disappearance of one of its nucleons.

NODE=S016T;LINKAGE=AR

NODE=S016T;LINKAGE=A4

NODE=S016T;LINKAGE=BK

NODE=S016T;LINKAGE=ZO

NODE=S016T;LINKAGE=KH

NODE=S016T;LINKAGE=BN

NODE=S016T;LINKAGE=E

NODE=S016T;LINKAGE=H

NODE=S016T;LINKAGE=F

NODE=S016TA

NODE=S016TA

NODE=S016TA

NODE=S016TA;LINKAGE=GE

NODE=S016225;NODE=S016

NODE=S016

LIMIT (years)	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$>8 \times 10^5$	90		34 GEER	00D	$\bar{p}/p$ ratio, cosmic rays
$>0.28$			GABRIELSE	90 TRAP	Penning trap
$>0.08$	90	1	BELL	79 CNTR	Storage ring
$>1 \times 10^7$			GOLDEN	79 SPEC	$\bar{p}/p$ ratio, cosmic rays
$>3.7 \times 10^{-3}$			BREGMAN	78 CNTR	Storage ring

34 GEER 00D uses agreement between a model of galactic  $\bar{p}$  production and propagation and the observed  $\bar{p}/p$  cosmic-ray spectrum to set this limit.

## $p$ DECAY MODES

See the “Note on Nucleon Decay” in our 1994 edition (Phys. Rev. **D50**, 1173) for a short review.

The “partial mean life” limits tabulated here are the limits on  $\tau/B_i$ , where  $\tau$  is the total mean life and  $B_i$  is the branching fraction for the mode in question. For *N* decays, *p* and *n* indicate proton and neutron partial lifetimes.

Mode	Partial mean life ( $10^{30}$ years)	Confidence level

<b>Antilepton + meson</b>			
$\tau_1$	$N \rightarrow e^+ \pi$	> 2000 ( <i>n</i> ), > 8200 ( <i>p</i> )	90% NODE=S016;CLUMP=B DESIG=6;OUR LIM
$\tau_2$	$N \rightarrow \mu^+ \pi$	> 1000 ( <i>n</i> ), > 6600 ( <i>p</i> )	90% DESIG=7;OUR LIM
$\tau_3$	$N \rightarrow \nu \pi$	> 112 ( <i>n</i> ), > 16 ( <i>p</i> )	90% DESIG=10;OUR LIM
$\tau_4$	$p \rightarrow e^+ \eta$	> 4200	90% DESIG=22;OUR LIM
$\tau_5$	$p \rightarrow \mu^+ \eta$	> 1300	90% DESIG=23;OUR LIM
$\tau_6$	$n \rightarrow \nu \eta$	> 158	90% DESIG=24;OUR LIM
$\tau_7$	$N \rightarrow e^+ \rho$	> 217 ( <i>n</i> ), > 710 ( <i>p</i> )	90% DESIG=14;OUR LIM
$\tau_8$	$N \rightarrow \mu^+ \rho$	> 228 ( <i>n</i> ), > 160 ( <i>p</i> )	90% DESIG=15;OUR LIM
$\tau_9$	$N \rightarrow \nu \rho$	> 19 ( <i>n</i> ), > 162 ( <i>p</i> )	90% DESIG=25;OUR LIM
$\tau_{10}$	$p \rightarrow e^+ \omega$	> 320	90% DESIG=12;OUR LIM
$\tau_{11}$	$p \rightarrow \mu^+ \omega$	> 780	90% DESIG=13;OUR LIM
$\tau_{12}$	$n \rightarrow \nu \omega$	> 108	90% DESIG=26;OUR LIM
$\tau_{13}$	$N \rightarrow e^+ K$	> 17 ( <i>n</i> ), > 1000 ( <i>p</i> )	90% DESIG=8;OUR LIM
$\tau_{14}$	$p \rightarrow e^+ K_S^0$		DESIG=50
$\tau_{15}$	$p \rightarrow e^+ K_L^0$		DESIG=51
$\tau_{16}$	$N \rightarrow \mu^+ K$	> 26 ( <i>n</i> ), > 1600 ( <i>p</i> )	90% DESIG=9;OUR LIM
$\tau_{17}$	$p \rightarrow \mu^+ K_S^0$		DESIG=52
$\tau_{18}$	$p \rightarrow \mu^+ K_L^0$		DESIG=53
$\tau_{19}$	$N \rightarrow \nu K$	> 86 ( <i>n</i> ), > 2300 ( <i>p</i> )	90% DESIG=11;OUR LIM
$\tau_{20}$	$n \rightarrow \nu K_S^0$	> 260	90% DESIG=99;OUR LIM
$\tau_{21}$	$p \rightarrow e^+ K^*(892)^0$	> 84	90% DESIG=34;OUR LIM
$\tau_{22}$	$N \rightarrow \nu K^*(892)$	> 78 ( <i>n</i> ), > 51 ( <i>p</i> )	90% DESIG=18;OUR LIM
<b>Antilepton + mesons</b>			
$\tau_{23}$	$p \rightarrow e^+ \pi^+ \pi^-$	> 82	90% NODE=S016;CLUMP=E DESIG=56;OUR LIM
$\tau_{24}$	$p \rightarrow e^+ \pi^0 \pi^0$	> 147	90% DESIG=57;OUR LIM
$\tau_{25}$	$n \rightarrow e^+ \pi^- \pi^0$	> 52	90% DESIG=58;OUR LIM
$\tau_{26}$	$p \rightarrow \mu^+ \pi^+ \pi^-$	> 133	90% DESIG=48;OUR LIM
$\tau_{27}$	$p \rightarrow \mu^+ \pi^0 \pi^0$	> 101	90% DESIG=59;OUR LIM
$\tau_{28}$	$n \rightarrow \mu^+ \pi^- \pi^0$	> 74	90% DESIG=60;OUR LIM
$\tau_{29}$	$n \rightarrow e^+ K^0 \pi^-$	> 18	90% DESIG=61;OUR LIM
<b>Lepton + meson</b>			
$\tau_{30}$	$n \rightarrow e^- \pi^+$	> 65	90% NODE=S016;CLUMP=F DESIG=29;OUR LIM
$\tau_{31}$	$n \rightarrow \mu^- \pi^+$	> 49	90% DESIG=30;OUR LIM
$\tau_{32}$	$n \rightarrow e^- \rho^+$	> 62	90% DESIG=31;OUR LIM
$\tau_{33}$	$n \rightarrow \mu^- \rho^+$	> 7	90% DESIG=32;OUR LIM
$\tau_{34}$	$n \rightarrow e^- K^+$	> 32	90% DESIG=33;OUR LIM
$\tau_{35}$	$n \rightarrow \mu^- K^+$	> 57	90% DESIG=35;OUR LIM
<b>Lepton + mesons</b>			
$\tau_{36}$	$p \rightarrow e^- \pi^+ \pi^+$	> 30	90% NODE=S016;CLUMP=G DESIG=47;OUR LIM
$\tau_{37}$	$n \rightarrow e^- \pi^+ \pi^0$	> 29	90% DESIG=39;OUR LIM
$\tau_{38}$	$p \rightarrow \mu^- \pi^+ \pi^+$	> 17	90% DESIG=49;OUR LIM
$\tau_{39}$	$n \rightarrow \mu^- \pi^+ \pi^0$	> 34	90% DESIG=40;OUR LIM
$\tau_{40}$	$p \rightarrow e^- \pi^+ K^+$	> 75	90% DESIG=41;OUR LIM
$\tau_{41}$	$p \rightarrow \mu^- \pi^+ K^+$	> 245	90% DESIG=42;OUR LIM
<b>Antilepton + photon(s)</b>			
$\tau_{42}$	$p \rightarrow e^+ \gamma$	> 670	90% NODE=S016;CLUMP=C DESIG=3;OUR LIM
$\tau_{43}$	$p \rightarrow \mu^+ \gamma$	> 478	90% DESIG=4;OUR LIM
$\tau_{44}$	$n \rightarrow \nu \gamma$	> 28	90% DESIG=5;OUR LIM
$\tau_{45}$	$p \rightarrow e^+ \gamma \gamma$	> 100	90% DESIG=54;OUR LIM
$\tau_{46}$	$n \rightarrow \nu \gamma \gamma$	> 219	90% DESIG=93;OUR LIM

**Three (or more) leptons**

$\tau_{47}$	$p \rightarrow e^+ e^+ e^-$	> 793	90%	NODE=S016;CLUMP=D DESIG=16;OUR LIM
$\tau_{48}$	$p \rightarrow e^+ \mu^+ \mu^-$	> 359	90%	DESIG=45;OUR LIM
$\tau_{49}$	$p \rightarrow e^+ \nu \nu$	> 17	90%	DESIG=36;OUR LIM
$\tau_{50}$	$n \rightarrow e^+ e^- \nu$	> 257	90%	DESIG=27;OUR LIM
$\tau_{51}$	$n \rightarrow \mu^+ e^- \nu$	> 83	90%	DESIG=37;OUR LIM
$\tau_{52}$	$n \rightarrow \mu^+ \mu^- \nu$	> 79	90%	DESIG=28;OUR LIM
$\tau_{53}$	$p \rightarrow \mu^+ e^+ e^-$	> 529	90%	DESIG=55;OUR LIM
$\tau_{54}$	$p \rightarrow \mu^+ \mu^+ \mu^-$	> 675	90%	DESIG=17;OUR LIM
$\tau_{55}$	$p \rightarrow \mu^+ \nu \nu$	> 21	90%	DESIG=38;OUR LIM
$\tau_{56}$	$p \rightarrow e^- \mu^+ \mu^+$	> 6	90%	DESIG=46;OUR LIM
$\tau_{57}$	$n \rightarrow 3\nu$	> 0.0005	90%	DESIG=21;OUR LIM
$\tau_{58}$	$n \rightarrow 5\nu$			DESIG=86

**Inclusive modes**

$\tau_{59}$	$N \rightarrow e^+ \text{anything}$	> 0.6 ( $n, p$ )	90%	NODE=S016;CLUMP=A DESIG=1;OUR LIM
$\tau_{60}$	$N \rightarrow \mu^+ \text{anything}$	> 12 ( $n, p$ )	90%	DESIG=2;OUR LIM
$\tau_{61}$	$N \rightarrow \nu \text{anything}$			DESIG=20
$\tau_{62}$	$N \rightarrow e^+ \pi^0 \text{anything}$	> 0.6 ( $n, p$ )	90%	DESIG=19;OUR LIM
$\tau_{63}$	$N \rightarrow 2 \text{ bodies, } \nu\text{-free}$			DESIG=191

 **$\Delta B = 2$  dinucleon modes**

The following are lifetime limits per iron nucleus.

$\tau_{64}$	$pp \rightarrow \pi^+ \pi^+$	> 0.7	90%	NODE=S016 DESIG=62;OUR LIM
$\tau_{65}$	$pn \rightarrow \pi^+ \pi^0$	> 2	90%	DESIG=63;OUR LIM
$\tau_{66}$	$nn \rightarrow \pi^+ \pi^-$	> 0.7	90%	DESIG=64;OUR LIM
$\tau_{67}$	$nn \rightarrow \pi^0 \pi^0$	> 3.4	90%	DESIG=65;OUR LIM
$\tau_{68}$	$pp \rightarrow e^+ e^+$	> 5.8	90%	DESIG=66;OUR LIM
$\tau_{69}$	$pp \rightarrow e^+ \mu^+$	> 3.6	90%	DESIG=67;OUR LIM
$\tau_{70}$	$pp \rightarrow \mu^+ \mu^+$	> 1.7	90%	DESIG=68;OUR LIM
$\tau_{71}$	$pn \rightarrow e^+ \bar{\nu}$	> 2.8	90%	DESIG=69;OUR LIM
$\tau_{72}$	$pn \rightarrow \mu^+ \bar{\nu}$	> 1.6	90%	DESIG=70;OUR LIM
$\tau_{73}$	$nn \rightarrow \nu_e \bar{\nu}_e$	> 1.4	90%	DESIG=71;OUR LIM
$\tau_{74}$	$nn \rightarrow \nu_\mu \bar{\nu}_\mu$	> 1.4	90%	DESIG=72;OUR LIM
$\tau_{75}$	$pn \rightarrow \text{invisible}$	> 0.000021	90%	DESIG=101;OUR LIM
$\tau_{76}$	$pp \rightarrow \text{invisible}$	> 0.0005	90%	DESIG=100;OUR LIM

 **$\bar{p}$  DECAY MODES**

Mode		Partial mean life (years)	Confidence level	
$\tau_{77}$	$\bar{p} \rightarrow e^- \gamma$	$> 7 \times 10^5$	90%	DESIG=81;OUR LIM
$\tau_{78}$	$\bar{p} \rightarrow \mu^- \gamma$	$> 5 \times 10^4$	90%	DESIG=87;OUR LIM
$\tau_{79}$	$\bar{p} \rightarrow e^- \pi^0$	$> 4 \times 10^5$	90%	DESIG=82;OUR LIM
$\tau_{80}$	$\bar{p} \rightarrow \mu^- \pi^0$	$> 5 \times 10^4$	90%	DESIG=88;OUR LIM
$\tau_{81}$	$\bar{p} \rightarrow e^- \eta$	$> 2 \times 10^4$	90%	DESIG=83;OUR LIM
$\tau_{82}$	$\bar{p} \rightarrow \mu^- \eta$	$> 8 \times 10^3$	90%	DESIG=89;OUR LIM
$\tau_{83}$	$\bar{p} \rightarrow e^- K_S^0$	> 900	90%	DESIG=84;OUR LIM
$\tau_{84}$	$\bar{p} \rightarrow \mu^- K_S^0$	$> 4 \times 10^3$	90%	DESIG=90;OUR LIM
$\tau_{85}$	$\bar{p} \rightarrow e^- K_L^0$	$> 9 \times 10^3$	90%	DESIG=85;OUR LIM
$\tau_{86}$	$\bar{p} \rightarrow \mu^- K_L^0$	$> 7 \times 10^3$	90%	DESIG=91;OUR LIM
$\tau_{87}$	$\bar{p} \rightarrow e^- \gamma \gamma$	$> 2 \times 10^4$	90%	DESIG=94;OUR LIM
$\tau_{88}$	$\bar{p} \rightarrow \mu^- \gamma \gamma$	$> 2 \times 10^4$	90%	DESIG=92;OUR LIM
$\tau_{89}$	$\bar{p} \rightarrow e^- \rho$			DESIG=95
$\tau_{90}$	$\bar{p} \rightarrow e^- \omega$	> 200	90%	DESIG=96;OUR LIM
$\tau_{91}$	$\bar{p} \rightarrow e^- K^*(892)^0$			DESIG=97

## $p$ PARTIAL MEAN LIVES

The "partial mean life" limits tabulated here are the limits on  $\tau/B_i$ , where  $\tau$  is the total mean life for the proton and  $B_i$  is the branching fraction for the mode in question.

Decaying particle:  $p$  = proton,  $n$  = bound neutron. The same event may appear under more than one partial decay mode. Background estimates may be accurate to a factor of two.

### Antilepton + meson

#### $\tau(N \rightarrow e^+ \pi)$

LIMIT ( $10^{30}$ years)	PARTICLE	CL%	EVTS	BKGD EST
>2000	$n$	90	0	0.27
>8200	$p$	90	0	0.3

• • • We do not use the following data for averages, fits, limits, etc. • • •

					DOCUMENT ID	TECN	$\tau_1$	NODE=S016T06 NODE=S016T06
> 540	$p$	90	0	0.2	MCGREW	99	IMB3	
> 158	$n$	90	3	5	MCGREW	99	IMB3	OCCUR=2
>1600	$p$	90	0	0.1	SHIOZAWA	98	SKAM	
> 70	$p$	90	0	0.5	BERGER	91	FREJ	
> 70	$n$	90	0	$\leq 0.1$	BERGER	91	FREJ	OCCUR=2
> 550	$p$	90	0	0.7	35 BECKER-SZ... 90	IMB3		
> 260	$p$	90	0	<0.04	HIRATA	89C	KAMI	
> 130	$n$	90	0	<0.2	HIRATA	89C	KAMI	OCCUR=2
> 310	$p$	90	0	0.6	SEIDEL	88	IMB	
> 100	$n$	90	0	1.6	SEIDEL	88	IMB	OCCUR=2
> 1.3	$n$	90	0		BARTEL	87	SOU	
> 1.3	$p$	90	0		BARTEL	87	SOU	OCCUR=2
> 250	$p$	90	0	0.3	HAINES	86	IMB	
> 31	$n$	90	8	9	HAINES	86	IMB	OCCUR=2
> 64	$p$	90	0	<0.4	ARISAKA	85	KAMI	
> 26	$n$	90	0	<0.7	ARISAKA	85	KAMI	OCCUR=2
> 82	$p$ (free)	90	0	0.2	BLEWITT	85	IMB	
> 250	$p$	90	0	0.2	BLEWITT	85	IMB	OCCUR=2
> 25	$n$	90	4	4	PARK	85	IMB	OCCUR=2
> 15	$p, n$	90	0		BATTISTONI	84	NUSX	
> 0.5	$p$	90	1	0.3	36 BARTEL 83	SOU		
> 0.5	$n$	90	1	0.3	BARTEL	83	SOU	OCCUR=2
> 5.8	$p$	90	2		37 KRISHNA... 82	KOLR		
> 5.8	$n$	90	2		KRISHNA...	82	KOLR	OCCUR=2
> 0.1	$n$	90			38 GURR 67	CNTR		

35 This BECKER-SZENDY 90 result includes data from SEIDEL 88.

36 Limit based on zero events.

37 We have calculated 90% CL limit from 1 confined event.

38 We have converted half-life to 90% CL mean life.

#### $\tau(N \rightarrow \mu^+ \pi)$

LIMIT ( $10^{30}$ years)	PARTICLE	CL%	EVTS	BKGD EST
>1000	$n$	90	1	0.43
>6600	$p$	90	0	0.3

• • • We do not use the following data for averages, fits, limits, etc. • • •

					DOCUMENT ID	TECN	$\tau_2$	NODE=S016T07 NODE=S016T07
> 473	$p$	90	0	0.6	MCGREW	99	IMB3	
> 90	$n$	90	1	1.9	MCGREW	99	IMB3	OCCUR=2
> 81	$p$	90	0	0.2	BERGER	91	FREJ	
> 35	$n$	90	1	1.0	BERGER	91	FREJ	OCCUR=2
> 230	$p$	90	0	<0.07	HIRATA	89C	KAMI	
> 100	$n$	90	0	<0.2	HIRATA	89C	KAMI	OCCUR=2
> 270	$p$	90	0	0.5	SEIDEL	88	IMB	
> 63	$n$	90	0	0.5	SEIDEL	88	IMB	OCCUR=2
> 76	$p$	90	2	1	HAINES	86	IMB	
> 23	$n$	90	8	7	HAINES	86	IMB	OCCUR=2
> 46	$p$	90	0	<0.7	ARISAKA	85	KAMI	
> 20	$n$	90	0	<0.4	ARISAKA	85	KAMI	OCCUR=2
> 59	$p$ (free)	90	0	0.2	BLEWITT	85	IMB	
> 100	$p$	90	1	0.4	BLEWITT	85	IMB	OCCUR=2
> 38	$n$	90	1	4	PARK	85	IMB	OCCUR=2
> 10	$p, n$	90	0		BATTISTONI	84	NUSX	
> 1.3	$p, n$	90	0		ALEKSEEV	81	BAKS	

NODE=S016230

NODE=S016230

NODE=S016305

NODE=S016T06  
NODE=S016T06

NODE=S016T07

NODE=S016T06;LINKAGE=L

NODE=S016T06;LINKAGE=B

NODE=S016T06;LINKAGE=K

NODE=S016T06;LINKAGE=G

$\tau(N \rightarrow \nu\pi)$ 

LIMIT ( $10^{30}$ years)	PARTICLE	CL%	EVTS	BKGD EST
> 16	p	90	6	6.7
> 12	n	90	6	6.6

• • • We do not use the following data for averages, fits, limits, etc. • • •

> 39	n	90	4	3.8	WALL	00B	SOU2
> 10	p	90	15	20.3	MCGREW	99	IMB3
> 13	n	90	1	1.2	BERGER	89	FREJ
> 10	p	90	11	14	BERGER	89	FREJ
> 25	p	90	32	32.8	39 HIRATA	89C	KAMI
> 100	n	90	1	3	HIRATA	89C	KAMI
> 6	n	90	73	60	HAINES	86	IMB
> 2	p	90	16	13	KAJITA	86	KAMI
> 40	n	90	0	1	KAJITA	86	KAMI
> 7	n	90	28	19	PARK	85	IMB
> 7	n	90	0		BATTISTONI	84	NUSX
> 2	p	90	≤ 3		BATTISTONI	84	NUSX
> 5.8	p	90	1		40 KRISHNA...	82	KOLR
> 0.3	p	90	2		41 CHERRY	81	HOME
> 0.1	p	90			42 GURR	67	CNTR

39 In estimating the background, this HIRATA 89C limit (as opposed to the later limits of WALL 00B and MCGREW 99) does not take into account present understanding that the flux of  $\nu_\mu$  originating in the upper atmosphere is depleted. Doing so would reduce the background and thus also would reduce the limit here.

40 We have calculated 90% CL limit from 1 confined event.

41 We have converted 2 possible events to 90% CL limit.

42 We have converted half-life to 90% CL mean life.

 $\tau_3$ 

NODE=S016T10  
NODE=S016T10

OCCUR=2

OCCUR=2

OCCUR=2

OCCUR=2

OCCUR=2

NODE=S016T10;LINKAGE=HI

 $\tau(p \rightarrow e^+ \eta)$ 

LIMIT ( $10^{30}$ years)	PARTICLE	CL%	EVTS	BKGD EST
> 4200	[ $> 313 \times 10^{30}$ years OUR 2012 BEST LIMIT]			
> 4200	p	90	0	0.44

• • • We do not use the following data for averages, fits, limits, etc. • • •

> 81	p	90	1	1.7	WALL	00B	SOU2
> 313	p	90	0	0.2	MCGREW	99	IMB3
> 44	p	90	0	0.1	BERGER	91	FREJ
> 140	p	90	0	<0.04	HIRATA	89C	KAMI
> 100	p	90	0	0.6	SEIDEL	88	IMB
> 200	p	90	5	3.3	HAINES	86	IMB
> 64	p	90	0	<0.8	ARISAKA	85	KAMI
> 64	p (free)	90	5	6.5	BLEWITT	85	IMB
> 200	p	90	5	4.7	BLEWITT	85	IMB
> 1.2	p	90	2		43 CHERRY	81	HOME

43 We have converted 2 possible events to 90% CL limit.

 $\tau_4$ 

NODE=S016T10;LINKAGE=K  
NODE=S016T10;LINKAGE=C  
NODE=S016T10;LINKAGE=G

NODE=S016T22  
NODE=S016T22

 $\tau(p \rightarrow \mu^+ \eta)$ 

LIMIT ( $10^{30}$ years)	PARTICLE	CL%	EVTS	BKGD EST
> 1300	[ $> 126 \times 10^{30}$ years OUR 2012 BEST LIMIT]			
> 1300	p	90	2	0.49

• • • We do not use the following data for averages, fits, limits, etc. • • •

> 89	p	90	0	1.6	WALL	00B	SOU2
> 126	p	90	3	2.8	MCGREW	99	IMB3
> 26	p	90	1	0.8	BERGER	91	FREJ
> 69	p	90	1	<0.08	HIRATA	89C	KAMI
> 1.3	p	90	0	0.7	PHILLIPS	89	HPW
> 34	p	90	1	1.5	SEIDEL	88	IMB
> 46	p	90	7	6	HAINES	86	IMB
> 26	p	90	1	<0.8	ARISAKA	85	KAMI
> 17	p (free)	90	6	6	BLEWITT	85	IMB
> 46	p	90	7	8	BLEWITT	85	IMB

 $\tau_5$ 

NODE=S016T23  
NODE=S016T23

OCCUR=2

$\tau(n \rightarrow \nu\eta)$ 

LIMIT ( $10^{30}$ years)	PARTICLE	CL%	EVTS	BKGD EST
>158	n	90	0	1.2

DOCUMENT ID	TECN
MCGREW	99

NODE=S016T24  
NODE=S016T24

• • • We do not use the following data for averages, fits, limits, etc. • • •

> 71	n	90	2	3.7	WALL	00B	SOU2
> 29	n	90	0	0.9	BERGER	89	FREJ
> 54	n	90	2	0.9	HIRATA	89C	KAMI
> 16	n	90	3	2.1	SEIDEL	88	IMB
> 25	n	90	7	6	HAINES	86	IMB
> 30	n	90	0	0.4	KAJITA	86	KAMI
> 18	n	90	4	3	PARK	85	IMB
> 0.6	n	90	2		<sup>44</sup> CHERRY	81	HOME

<sup>44</sup>We have converted 2 possible events to 90% CL limit.

NODE=S016T24;LINKAGE=C

 $\tau(N \rightarrow e^+ \rho)$ 

LIMIT ( $10^{30}$ years)	PARTICLE	CL%	EVTS	BKGD EST
>217	[ $>75 \times 10^{30}$ years OUR 2012 BEST LIMIT]			
>710	p	90	0	0.35
>217	n	90	4	4.8

DOCUMENT ID	TECN
NISHINO	12
MCGREW	99

NODE=S016T14  
NODE=S016T14

• • • We do not use the following data for averages, fits, limits, etc. • • •

> 70	n	90	1	0.38	NISHINO	12	SKAM		OCCUR=2
> 29	p	90	0	2.2	BERGER	91	FREJ		
> 41	n	90	0	1.4	BERGER	91	FREJ		OCCUR=2
> 75	p	90	2	2.7	HIRATA	89C	KAMI		
> 58	n	90	0	1.9	HIRATA	89C	KAMI		OCCUR=2
> 38	n	90	2	4.1	SEIDEL	88	IMB		
> 1.2	p	90	0		BARTEL	87	SOUD		
> 1.5	n	90	0		BARTEL	87	SOUD		OCCUR=2
> 17	p	90	7	7	HAINES	86	IMB		
> 14	n	90	9	4	HAINES	86	IMB		OCCUR=2
> 12	p	90	0	<1.2	ARISAKA	85	KAMI		
> 6	n	90	2	<1	ARISAKA	85	KAMI		OCCUR=2
> 6.7	p (free)	90	6	6	BLEWITT	85	IMB		
> 17	p	90	7	7	BLEWITT	85	IMB		OCCUR=2
> 12	n	90	4	2	PARK	85	IMB		OCCUR=2
> 0.6	n	90	1	0.3	<sup>45</sup> BARTEL	83	SOUD		
> 0.5	p	90	1	0.3	<sup>45</sup> BARTEL	83	SOUD		OCCUR=2
> 9.8	p	90	1		<sup>46</sup> KRISHNA...	82	KOLR		
> 0.8	p	90	2		<sup>47</sup> CHERRY	81	HOME		

<sup>45</sup>Limit based on zero events.

NODE=S016T14;LINKAGE=B

<sup>46</sup>We have calculated 90% CL limit from 0 confined events.

<sup>47</sup>We have converted 2 possible events to 90% CL limit.

NODE=S016T14;LINKAGE=K

NODE=S016T14;LINKAGE=C

 $\tau(N \rightarrow \mu^+ \rho)$ 

LIMIT ( $10^{30}$ years)	PARTICLE	CL%	EVTS	BKGD EST
>228	[ $>110 \times 10^{30}$ years OUR 2012 BEST LIMIT]			
>160	p	90	1	0.42

DOCUMENT ID	TECN
NISHINO	12
MCGREW	99

NODE=S016T15  
NODE=S016T15

• • • We do not use the following data for averages, fits, limits, etc. • • •

> 36	n	90	0	0.29	NISHINO	12	SKAM		OCCUR=2
> 12	p	90	0	0.5	BERGER	91	FREJ		
> 22	n	90	0	1.1	BERGER	91	FREJ		OCCUR=2
> 110	p	90	0	1.7	HIRATA	89C	KAMI		
> 23	n	90	1	1.8	HIRATA	89C	KAMI		OCCUR=2
> 4.3	p	90	0	0.7	PHILLIPS	89	HPW		
> 30	p	90	0	0.5	SEIDEL	88	IMB		
> 11	n	90	1	1.1	SEIDEL	88	IMB		OCCUR=2
> 16	p	90	4	4.5	HAINES	86	IMB		
> 7	n	90	6	5	HAINES	86	IMB		OCCUR=2
> 12	p	90	0	<0.7	ARISAKA	85	KAMI		
> 5	n	90	1	<1.2	ARISAKA	85	KAMI		OCCUR=2
> 5.5	p (free)	90	4	5	BLEWITT	85	IMB		
> 16	p	90	4	5	BLEWITT	85	IMB		OCCUR=2
> 9	n	90	1	2	PARK	85	IMB		OCCUR=2

$\tau(N \rightarrow \nu\rho)$ 

LIMIT ( $10^{30}$ years)	PARTICLE	CL%	EVTS	BKGD EST
>162	p	90	18	21.7
> 19	n	90	0	0.5

• • • We do not use the following data for averages, fits, limits, etc. • • •

> 9	n	90	4	2.4	BERGER	89	FREJ
> 24	p	90	0	0.9	BERGER	89	FREJ
> 27	p	90	5	1.5	HIRATA	89c	KAMI
> 13	n	90	4	3.6	HIRATA	89c	KAMI
> 13	p	90	1	1.1	SEIDEL	88	IMB
> 8	p	90	6	5	HAINES	86	IMB
> 2	n	90	15	10	HAINES	86	IMB
> 11	p	90	2	1	KAJITA	86	KAMI
> 4	n	90	2	2	KAJITA	86	KAMI
> 4.1	p (free)	90	6	7	BLEWITT	85	IMB
> 8.4	p	90	6	5	BLEWITT	85	IMB
> 2	n	90	7	3	PARK	85	IMB
> 0.9	p	90	2		48 CHERRY	81	HOME
> 0.6	n	90	2		48 CHERRY	81	HOME

48 We have converted 2 possible events to 90% CL limit.

NODE=S016T25  
NODE=S016T25

 $\tau(p \rightarrow e^+ \omega)$ 

LIMIT ( $10^{30}$ years)	PARTICLE	CL%	EVTS	BKGD EST
>320	[>107 $\times 10^{30}$ years OUR 2012 BEST LIMIT]			
>320	p	90	1	0.53

• • • We do not use the following data for averages, fits, limits, etc. • • •

>107	p	90	7	10.8	MCGREW	99	IMB3
> 17	p	90	0	1.1	BERGER	91	FREJ
> 45	p	90	2	1.45	HIRATA	89c	KAMI
> 26	p	90	1	1.0	SEIDEL	88	IMB
> 1.5	p	90	0		BARTEL	87	SOUD
> 37	p	90	6	5.3	HAINES	86	IMB
> 25	p	90	1	<1.4	ARISAKA	85	KAMI
> 12	p (free)	90	6	7.5	BLEWITT	85	IMB
> 37	p	90	6	5.7	BLEWITT	85	IMB
> 0.6	p	90	1	0.3	49 BARTEL	83	SOUD
> 9.8	p	90	1		50 KRISHNA...	82	KOLR
> 2.8	p	90	2		51 CHERRY	81	HOME

49 Limit based on zero events.

50 We have calculated 90% CL limit from 0 confined events.

51 We have converted 2 possible events to 90% CL limit.

NODE=S016T12  
NODE=S016T12

 $\tau(p \rightarrow \mu^+ \omega)$ 

LIMIT ( $10^{30}$ years)	PARTICLE	CL%	EVTS	BKGD EST
>780	[>117 $\times 10^{30}$ years OUR 2012 BEST LIMIT]			
>780	p	90	0	0.48

• • • We do not use the following data for averages, fits, limits, etc. • • •

>117	p	90	11	12.1	MCGREW	99	IMB3
> 11	p	90	0	1.0	BERGER	91	FREJ
> 57	p	90	2	1.9	HIRATA	89c	KAMI
> 4.4	p	90	0	0.7	PHILLIPS	89	HPW
> 10	p	90	2	1.3	SEIDEL	88	IMB
> 23	p	90	2	1	HAINES	86	IMB
> 6.5	p (free)	90	9	8.7	BLEWITT	85	IMB
> 23	p	90	8	7	BLEWITT	85	IMB

NODE=S016T13  
NODE=S016T13

 $\tau(n \rightarrow \nu\omega)$ 

LIMIT ( $10^{30}$ years)	PARTICLE	CL%	EVTS	BKGD EST
>108	n	90	12	22.5

DOCUMENT ID	TECN
MCGREW	99

NODE=S016T26  
NODE=S016T26

• • • We do not use the following data for averages, fits, limits, etc. • • •

> 17	<i>n</i>	90	1 0.7	BERGER	89	FREJ
> 43	<i>n</i>	90	3 2.7	HIRATA	89C	KAMI
> 6	<i>n</i>	90	2 1.3	SEIDEL	88	IMB
> 12	<i>n</i>	90	6 6	HAINES	86	IMB
> 18	<i>n</i>	90	2 2	KAJITA	86	KAMI
> 16	<i>n</i>	90	1 2	PARK	85	IMB
> 2.0	<i>n</i>	90	2	52 CHERRY	81	HOME

52 We have converted 2 possible events to 90% CL limit.

NODE=S016T26;LINKAGE=C

### $\tau(N \rightarrow e^+ K)$

T13

LIMIT ( $10^{30}$ years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID	TECN
$> 17$ [ $> 150 \times 10^{30}$ years OUR 2012 BEST LIMIT]						
>1000	p	90	6	4.7	KOBAYASHI	05 SKAM
> 17	<i>n</i>	90	35	29.4	MCGREW	99 IMB3

NODE=S016T08  
NODE=S016T08

• • • We do not use the following data for averages, fits, limits, etc. • • •

> 85	<i>p</i>	90	3 4.9	WALL	00	SOU2
> 31	<i>p</i>	90	23 25.2	MCGREW	99	IMB3
> 60	<i>p</i>	90	0	BERGER	91	FREJ
> 150	<i>p</i>	90	0 <0.27	HIRATA	89C	KAMI
> 70	<i>p</i>	90	0 1.8	SEIDEL	88	IMB
> 77	<i>p</i>	90	5 4.5	HAINES	86	IMB
> 38	<i>p</i>	90	0 <0.8	ARISAKA	85	KAMI
> 24	<i>p</i> (free)	90	7 8.5	BLEWITT	85	IMB
> 77	<i>p</i>	90	5 4	BLEWITT	85	IMB
> 1.3	<i>p</i>	90	0	ALEKSEEV	81	BAKS
> 1.3	<i>n</i>	90	0	ALEKSEEV	81	BAKS

OCCUR=2

### $\tau(p \rightarrow e^+ K_0^0)$

T14

LIMIT ( $10^{30}$ years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID	TECN
• • • We do not use the following data for averages, fits, limits, etc. • • •						
>120	<i>p</i>	90	1 1.3	WALL	00	SOU2
> 76	<i>p</i>	90	0 0.5	BERGER	91	FREJ

NODE=S016T42  
NODE=S016T42

### $\tau(p \rightarrow e^+ K_L^0)$

T15

LIMIT ( $10^{30}$ years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID	TECN
• • • We do not use the following data for averages, fits, limits, etc. • • •						
>51	<i>p</i>	90	2 3.5	WALL	00	SOU2
>44	<i>p</i>	90	0 $\leq 0.1$	BERGER	91	FREJ

NODE=S016T43  
NODE=S016T43

### $\tau(N \rightarrow \mu^+ K)$

T16

LIMIT ( $10^{30}$ years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID	TECN
$> 26$ [ $> 120 \times 10^{30}$ years OUR 2012 BEST LIMIT]						
>1600	<i>p</i>	90	13	13.2	REGIS	12 SKAM
> 26	<i>n</i>	90	20	28.4	MCGREW	99 IMB3
• • • We do not use the following data for averages, fits, limits, etc. • • •						
>1300	<i>p</i>	90	3 3.9	KOBAYASHI	05	SKAM
> 120	<i>p</i>	90	0 <1.2	WALL	00	SOU2
> 120	<i>p</i>	90	4 7.2	MCGREW	99	IMB3
> 54	<i>p</i>	90	0	BERGER	91	FREJ
> 120	<i>p</i>	90	1 0.4	HIRATA	89C	KAMI
> 3.0	<i>p</i>	90	0 0.7	PHILLIPS	89	HPW
> 19	<i>p</i>	90	3 2.5	SEIDEL	88	IMB
> 1.5	<i>p</i>	90	0	53 BARTEL	87	SOU2
> 1.1	<i>n</i>	90	0	BARTEL	87	SOU2
> 40	<i>p</i>	90	7 6	HAINES	86	IMB
> 19	<i>p</i>	90	1 <1.1	ARISAKA	85	KAMI
> 6.7	<i>p</i> (free)	90	11	BLEWITT	85	IMB
> 40	<i>p</i>	90	7 8	BLEWITT	85	IMB
> 6	<i>p</i>	90	1	54 BARTEL	83	SOU2
> 0.6	<i>p</i>	90	0	54 BARTEL	83	SOU2
> 0.4	<i>n</i>	90	0	55 KRISHNA...	82	KOLR
> 5.8	<i>p</i>	90	2	CHERRY	81	HOME
> 2.0	<i>p</i>	90	0	56 GURR	67	CNTR
> 0.2	<i>n</i>	90				

NODE=S016T09  
NODE=S016T09

OCCUR=2

OCCUR=2

OCCUR=2

OCCUR=2

53 BARTEL T 87 limit applies to  $p \rightarrow \mu^+ K_S^0$ .

54 Limit based on zero events.

55 We have calculated 90% CL limit from 1 confined event.

56 We have converted half-life to 90% CL mean life.

### $\tau(p \rightarrow \mu^+ K_S^0)$

LIMIT ( $10^{30}$ years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID	TECN
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• • • We do not use the following data for averages, fits, limits, etc. • • •

>150	$p$	90	0	<0.8	WALL	00	SOU2
> 64	$p$	90	0	1.2	BERGER	91	FREJ

T17

NODE=S016T09;LINKAGE=S  
NODE=S016T09;LINKAGE=B  
NODE=S016T09;LINKAGE=K  
NODE=S016T09;LINKAGE=G

### $\tau(p \rightarrow \mu^+ K_L^0)$

LIMIT ( $10^{30}$ years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID	TECN
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• • • We do not use the following data for averages, fits, limits, etc. • • •

>83	$p$	90	0	0.4	WALL	00	SOU2
>44	$p$	90	0	$\leq 0.1$	BERGER	91	FREJ

T18

NODE=S016T45  
NODE=S016T45

### $\tau(N \rightarrow \nu K)$

LIMIT ( $10^{30}$ years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID	TECN
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<b>&gt;2300</b>	$p$	<b>90</b>	<b>0</b>	<b>1.3</b>	KOBAYASHI	05	SKAM
<b>&gt; 86</b>	$n$	<b>90</b>	<b>0</b>	<b>2.4</b>	HIRATA	89C	KAMI

• • • We do not use the following data for averages, fits, limits, etc. • • •

> 26	$n$	90	16	9.1	WALL	00	SOU2
> 670	$p$	90			HAYATO	99	SKAM
> 151	$p$	90	15	21.4	MCGREW	99	IMB3
> 30	$n$	90	34	34.1	MCGREW	99	IMB3
> 43	$p$	90	1	1.54	57 ALLISON	98	SOU2
> 15	$n$	90	1	1.8	BERGER	89	FREJ
> 15	$p$	90	1	1.8	BERGER	89	FREJ
> 100	$p$	90	9	7.3	HIRATA	89C	KAMI
> 0.28	$p$	90	0	0.7	PHILLIPS	89	HPW
> 0.3	$p$	90	0		BARTEL T	87	SOUD
> 0.75	$n$	90	0		58 BARTEL T	87	SOUD
> 10	$p$	90	6	5	HAINES	86	IMB
> 15	$n$	90	3	5	HAINES	86	IMB
> 28	$p$	90	3	3	KAJITA	86	KAMI
> 32	$n$	90	0	1.4	KAJITA	86	KAMI
> 1.8	$p$ (free)	90	6	11	BLEWITT	85	IMB
> 9.6	$p$	90	6	5	BLEWITT	85	IMB
> 10	$n$	90	2	2	PARK	85	IMB
> 5	$n$	90	0		BATTISTONI	84	NUSX
> 2	$p$	90	0		BATTISTONI	84	NUSX
> 0.3	$n$	90	0		59 BARTEL T	83	SOUD
> 0.1	$p$	90	0		59 BARTEL T	83	SOUD
> 5.8	$p$	90	1		60 KRISHNA...	82	KOLR
> 0.3	$n$	90	2		61 CHERRY	81	HOME

T19

NODE=S016T11  
NODE=S016T11

57 This ALLISON 98 limit is with no background subtraction; with subtraction the limit becomes  $> 46 \times 10^{30}$  years.

58 BARTEL T 87 limit applies to  $n \rightarrow \nu K_S^0$ .

59 Limit based on zero events.

60 We have calculated 90% CL limit from 1 confined event.

61 We have converted 2 possible events to 90% CL limit.

NODE=S016T11;LINKAGE=A

### $\tau(n \rightarrow \nu K_S^0)$

LIMIT ( $10^{30}$ years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID	TECN
-----------------------------	----------	-----	------	----------	-------------	------

<b>&gt;260</b>	$n$	<b>90</b>	<b>34</b>	<b>30</b>	62 KOBAYASHI	05	SKAM
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T20

NODE=S016T75  
NODE=S016T75

• • • We do not use the following data for averages, fits, limits, etc. • • •

> 51	$n$	90	16	9.1	WALL	00	SOU2
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62 We have doubled the  $n \rightarrow \nu K^0$  limit given in KOBAYASHI 05 to obtain this  $n \rightarrow \nu K_S^0$  limit.

NODE=S016T75;LINKAGE=KO

$\tau(p \rightarrow e^+ K^*(892)^0)$ 

LIMIT ( $10^{30}$ years)	PARTICLE	CL%	EVTS	BKGD EST
>84	p	90	38	52.0

• • • We do not use the following data for averages, fits, limits, etc. • • •

>10	p	90	0	0.8
>52	p	90	2	1.55
>10	p	90	1	<1

 $\tau_{21}$ 

NODE=S016T34  
NODE=S016T34

 $\tau(N \rightarrow \nu K^*(892))$ 

LIMIT ( $10^{30}$ years)	PARTICLE	CL%	EVTS	BKGD EST
>51	p	90	7	9.1
>78	n	90	40	50

• • • We do not use the following data for averages, fits, limits, etc. • • •

>22	n	90	0	2.1
>17	p	90	0	2.4
>20	p	90	5	2.1
>21	n	90	4	2.4
>10	p	90	7	6
> 5	n	90	8	7
> 8	p	90	3	2
> 6	n	90	2	1.6
> 5.8	p (free)	90	10	16
> 9.6	p	90	7	6
> 7	n	90	1	4
> 2.1	p	90	1	

 $\tau_{22}$ 

NODE=S016T18  
NODE=S016T18

63 We have converted 1 possible event to 90% CL limit.

**Antilepton + mesons** $\tau(p \rightarrow e^+ \pi^+ \pi^-)$ 

LIMIT ( $10^{30}$ years)	PARTICLE	CL%	EVTS	BKGD EST
>82	p	90	16	23.1

• • • We do not use the following data for averages, fits, limits, etc. • • •

>21	p	90	0	2.2
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 $\tau_{23}$ 

NODE=S016T48  
NODE=S016T48

 $\tau(p \rightarrow e^+ \pi^0 \pi^0)$ 

LIMIT ( $10^{30}$ years)	PARTICLE	CL%	EVTS	BKGD EST
>147	p	90	2	0.8

• • • We do not use the following data for averages, fits, limits, etc. • • •

> 38	p	90	1	0.5
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 $\tau_{24}$ 

NODE=S016T49  
NODE=S016T49

 $\tau(n \rightarrow e^+ \pi^- \pi^0)$ 

LIMIT ( $10^{30}$ years)	PARTICLE	CL%	EVTS	BKGD EST
>52	n	90	38	34.2

• • • We do not use the following data for averages, fits, limits, etc. • • •

>32	n	90	1	0.8
-----	---	----	---	-----

 $\tau_{25}$ 

NODE=S016T50  
NODE=S016T50

 $\tau(p \rightarrow \mu^+ \pi^+ \pi^-)$ 

LIMIT ( $10^{30}$ years)	PARTICLE	CL%	EVTS	BKGD EST
>133	p	90	25	38.0

• • • We do not use the following data for averages, fits, limits, etc. • • •

> 17	p	90	1	2.6
> 3.3	p	90	0	0.7

 $\tau_{26}$ 

NODE=S016T38  
NODE=S016T38

 $\tau(p \rightarrow \mu^+ \pi^0 \pi^0)$ 

LIMIT ( $10^{30}$ years)	PARTICLE	CL%	EVTS	BKGD EST
>101	p	90	3	1.6

• • • We do not use the following data for averages, fits, limits, etc. • • •

> 33	p	90	1	0.9
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 $\tau_{27}$ 

NODE=S016T51  
NODE=S016T51

$\tau(n \rightarrow \mu^+ \pi^- \pi^0)$ 

<u>LIMIT</u> ( $10^{30}$ years)	<u>PARTICLE</u>	<u>CL%</u>	<u>EVTS</u>	<u>BKGD EST</u>
>74	n	90	17	20.8

<u>DOCUMENT ID</u>	<u>TECN</u>
MCGREW	99

• • • We do not use the following data for averages, fits, limits, etc. • • •

>33	n	90	0	1.1
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BERGER	91	FREJ
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**T28**

NODE=S016T52  
NODE=S016T52

 $\tau(n \rightarrow e^+ K^0 \pi^-)$ 

<u>LIMIT</u> ( $10^{30}$ years)	<u>PARTICLE</u>	<u>CL%</u>	<u>EVTS</u>	<u>BKGD EST</u>
>18	n	90	1	0.2

<u>DOCUMENT ID</u>	<u>TECN</u>
BERGER	91

**T29**

NODE=S016T53  
NODE=S016T53

**Lepton + meson** $\tau(n \rightarrow e^- \pi^+)$ 

<u>LIMIT</u> ( $10^{30}$ years)	<u>PARTICLE</u>	<u>CL%</u>	<u>EVTS</u>	<u>BKGD EST</u>
>65	n	90	0	1.6

<u>DOCUMENT ID</u>	<u>TECN</u>
SEIDEL	88

**T30**

NODE=S016T29  
NODE=S016T29

• • • We do not use the following data for averages, fits, limits, etc. • • •

>55	n	90	0	1.09
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BERGER	91B	FREJ
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>16	n	90	9	7
-----	---	----	---	---

HAINES	86	IMB
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>25	n	90	2	4
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PARK	85	IMB
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 $\tau(n \rightarrow \mu^- \pi^+)$ 

<u>LIMIT</u> ( $10^{30}$ years)	<u>PARTICLE</u>	<u>CL%</u>	<u>EVTS</u>	<u>BKGD EST</u>
>49	n	90	0	0.5

<u>DOCUMENT ID</u>	<u>TECN</u>
SEIDEL	88

**T31**

NODE=S016T30  
NODE=S016T30

• • • We do not use the following data for averages, fits, limits, etc. • • •

>33	n	90	0	1.40
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BERGER	91B	FREJ
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>2.7	n	90	0	0.7
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PHILLIPS	89	HPW
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>25	n	90	7	6
-----	---	----	---	---

HAINES	86	IMB
--------	----	-----

>27	n	90	2	3
-----	---	----	---	---

PARK	85	IMB
------	----	-----

 $\tau(n \rightarrow e^- \rho^+)$ 

<u>LIMIT</u> ( $10^{30}$ years)	<u>PARTICLE</u>	<u>CL%</u>	<u>EVTS</u>	<u>BKGD EST</u>
>62	n	90	2	4.1

<u>DOCUMENT ID</u>	<u>TECN</u>
SEIDEL	88

**T32**

NODE=S016T31  
NODE=S016T31

• • • We do not use the following data for averages, fits, limits, etc. • • •

>12	n	90	13	6
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HAINES	86	IMB
--------	----	-----

>12	n	90	5	3
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PARK	85	IMB
------	----	-----

 $\tau(n \rightarrow \mu^- \rho^+)$ 

<u>LIMIT</u> ( $10^{30}$ years)	<u>PARTICLE</u>	<u>CL%</u>	<u>EVTS</u>	<u>BKGD EST</u>
>7	n	90	2	4.1

<u>DOCUMENT ID</u>	<u>TECN</u>
SEIDEL	88

**T33**

NODE=S016T32  
NODE=S016T32

• • • We do not use the following data for averages, fits, limits, etc. • • •

>2.6	n	90	0	0.7
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PHILLIPS	89	HPW
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>9	n	90	7	5
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HAINES	86	IMB
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>9	n	90	2	2
----	---	----	---	---

PARK	85	IMB
------	----	-----

 $\tau(n \rightarrow e^- K^+)$ 

<u>LIMIT</u> ( $10^{30}$ years)	<u>PARTICLE</u>	<u>CL%</u>	<u>EVTS</u>	<u>BKGD EST</u>
>32	n	90	3	2.96

<u>DOCUMENT ID</u>	<u>TECN</u>
BERGER	91B

**T34**

NODE=S016T40  
NODE=S016T40

• • • We do not use the following data for averages, fits, limits, etc. • • •

> 0.23	n	90	0	0.7
--------	---	----	---	-----

PHILLIPS	89	HPW
----------	----	-----

 $\tau(n \rightarrow \mu^- K^+)$ 

<u>LIMIT</u> ( $10^{30}$ years)	<u>PARTICLE</u>	<u>CL%</u>	<u>EVTS</u>	<u>BKGD EST</u>
>57	n	90	0	2.18

<u>DOCUMENT ID</u>	<u>TECN</u>
BERGER	91B

**T35**

NODE=S016T41  
NODE=S016T41

• • • We do not use the following data for averages, fits, limits, etc. • • •

> 4.7	n	90	0	0.7
-------	---	----	---	-----

PHILLIPS	89	HPW
----------	----	-----

**Lepton + mesons** **$\tau(p \rightarrow e^- \pi^+ \pi^+)$** 

LIMIT ( $10^{30}$ years)	PARTICLE	CL%	EVTS	BKGD EST
>30	p	90	1	2.50

**T36**

NODE=S016320

• • • We do not use the following data for averages, fits, limits, etc. • • •

&gt; 2.0 p 90 0 0.7

DOCUMENT ID	TECN
BERGER	91B FREJ

PHILLIPS 89 HPW

 **$\tau(n \rightarrow e^- \pi^+ \pi^0)$** 

LIMIT ( $10^{30}$ years)	PARTICLE	CL%	EVTS	BKGD EST
>29	n	90	1	0.78

**T37**NODE=S016T57  
NODE=S016T57

DOCUMENT ID	TECN
BERGER	91B FREJ

 **$\tau(p \rightarrow \mu^- \pi^+ \pi^+)$** 

LIMIT ( $10^{30}$ years)	PARTICLE	CL%	EVTS	BKGD EST
>17	p	90	1	1.72

**T38**NODE=S016T39  
NODE=S016T39

• • • We do not use the following data for averages, fits, limits, etc. • • •

&gt; 7.8 p 90 0 0.7

DOCUMENT ID	TECN
BERGER	91B FREJ

PHILLIPS 89 HPW

 **$\tau(n \rightarrow \mu^- \pi^+ \pi^0)$** 

LIMIT ( $10^{30}$ years)	PARTICLE	CL%	EVTS	BKGD EST
>34	n	90	0	0.78

**T39**NODE=S016T58  
NODE=S016T58

DOCUMENT ID	TECN
BERGER	91B FREJ

 **$\tau(p \rightarrow e^- \pi^+ K^+)$** 

LIMIT ( $10^{30}$ years)	PARTICLE	CL%	EVTS	BKGD EST
>75	p	90	81	127.2

**T40**NODE=S016T59  
NODE=S016T59

• • • We do not use the following data for averages, fits, limits, etc. • • •

&gt; 20 p 90 3 2.50

DOCUMENT ID	TECN
MCGREW	99 IMB3

BERGER 91B FREJ

 **$\tau(p \rightarrow \mu^- \pi^+ K^+)$** 

LIMIT ( $10^{30}$ years)	PARTICLE	CL%	EVTS	BKGD EST
>245	p	90	3	4.0

**T41**NODE=S016T60  
NODE=S016T60

• • • We do not use the following data for averages, fits, limits, etc. • • •

&gt; 5 p 90 2 0.78

DOCUMENT ID	TECN
MCGREW	99 IMB3

BERGER 91B FREJ

**Antilepton + photon(s)** **$\tau(p \rightarrow e^+ \gamma)$** 

LIMIT ( $10^{30}$ years)	PARTICLE	CL%	EVTS	BKGD EST
>670	p	90	0	0.1

**T42**NODE=S016T03  
NODE=S016T03

• • • We do not use the following data for averages, fits, limits, etc. • • •

&gt; 133 p 90 0 0.3

DOCUMENT ID	TECN
MCGREW	99 IMB3

BERGER 91 FREJ

&gt; 460 p 90 0 0.6

SEIDEL 88 IMB

&gt; 360 p 90 0 0.3

HAINES 86 IMB

&gt; 87 p (free) 90 0 0.2

BLEWITT 85 IMB

&gt; 360 p 90 0 0.2

BLEWITT 85 IMB

&gt; 0.1 p 90 0 0.78

64 GURR 67 CNTR

OCCUR=2

64 We have converted half-life to 90% CL mean life.

NODE=S016T03;LINKAGE=C

 **$\tau(p \rightarrow \mu^+ \gamma)$** 

LIMIT ( $10^{30}$ years)	PARTICLE	CL%	EVTS	BKGD EST
>478	p	90	0	0.1

**T43**NODE=S016T04  
NODE=S016T04

• • • We do not use the following data for averages, fits, limits, etc. • • •

&gt; 155 p 90 0 0.1

BERGER 91 FREJ

&gt; 380 p 90 0 0.5

SEIDEL 88 IMB

&gt; 97 p 90 3 2

HAINES 86 IMB

&gt; 61 p (free) 90 0 0.2

BLEWITT 85 IMB

&gt; 280 p 90 0 0.6

BLEWITT 85 IMB

&gt; 0.3 p 90 0 0.78

65 GURR 67 CNTR

OCCUR=2

65 We have converted half-life to 90% CL mean life.

NODE=S016T04;LINKAGE=C

$\tau(n \rightarrow \nu\gamma)$ 

LIMIT ( $10^{30}$ years)	PARTICLE	CL%	EVTS	BKGD EST
>28	n	90	163	144.7

• • • We do not use the following data for averages, fits, limits, etc. • • •

>24	n	90	10	6.86
> 9	n	90	73	60
>11	n	90	28	19

**T44**

NODE=S016T05  
NODE=S016T05

 $\tau(p \rightarrow e^+\gamma\gamma)$ 

LIMIT ( $10^{30}$ years)	PARTICLE	CL%	EVTS	BKGD EST
>100	p	90	1	0.8

**T45**

NODE=S016T46  
NODE=S016T46

 $\tau(n \rightarrow \nu\gamma\gamma)$ 

LIMIT ( $10^{30}$ years)	PARTICLE	CL%	EVTS	BKGD EST
>219	n	90	5	7.5

**T46**

NODE=S016T74  
NODE=S016T74

**Three (or more) leptons**

NODE=S016330

 $\tau(p \rightarrow e^+e^+e^-)$ 

LIMIT ( $10^{30}$ years)	PARTICLE	CL%	EVTS	BKGD EST
>793	p	90	0	0.5

**T47**

NODE=S016T16  
NODE=S016T16

• • • We do not use the following data for averages, fits, limits, etc. • • •

>147	p	90	0	0.1
>510	p	90	0	0.3
> 89	p (free)	90	0	0.5
>510	p	90	0	0.7

OCCUR=2

 $\tau(p \rightarrow e^+\mu^+\mu^-)$ **T48**

NODE=S016T35  
NODE=S016T35

LIMIT ( $10^{30}$ years)	PARTICLE	CL%	EVTS	BKGD EST
>359	p	90	1	0.9

• • • We do not use the following data for averages, fits, limits, etc. • • •

> 81	p	90	0	0.16
> 5.0	p	90	0	0.7

PHILLIPS

89 HPW

 $\tau(p \rightarrow e^+\nu\nu)$ **T49**

NODE=S016T54  
NODE=S016T54

LIMIT ( $10^{30}$ years)	PARTICLE	CL%	EVTS	BKGD EST
>17	p	90	152	153.7

• • • We do not use the following data for averages, fits, limits, etc. • • •

>11	p	90	11	6.08
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BERGER

91B FREJ

 $\tau(n \rightarrow e^+e^-\nu)$ **T50**

NODE=S016T27  
NODE=S016T27

LIMIT ( $10^{30}$ years)	PARTICLE	CL%	EVTS	BKGD EST
>257	n	90	5	7.5

• • • We do not use the following data for averages, fits, limits, etc. • • •

> 74	n	90	0	< 0.1
> 45	n	90	5	5
> 26	n	90	4	3

BERGER

91B FREJ

HAINES

86 IMB

PARK

85 IMB

LIMIT ( $10^{30}$ years)	PARTICLE	CL%	EVTS	BKGD EST
>83	n	90	25	29.4

• • • We do not use the following data for averages, fits, limits, etc. • • •

>47	n	90	0	< 0.1
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**T51**

NODE=S016T55  
NODE=S016T55

LIMIT ( $10^{30}$ years)	PARTICLE	CL%	EVTS	BKGD EST
>83	n	90	25	29.4

• • • We do not use the following data for averages, fits, limits, etc. • • •

BERGER

91B FREJ

$\tau(n \rightarrow \mu^+ \mu^- \nu)$ 

LIMIT ( $10^{30}$ years)	PARTICLE	CL%	EVTS	BKGD EST
>79	n	90	100	145

DOCUMENT ID	TECN
MCGREW	99

• • • We do not use the following data for averages, fits, limits, etc. • • •

>42	n	90	0	1.4
> 5.1	n	90	0	0.7
>16	n	90	14	7
>19	n	90	4	7

BERGER	91B	FREJ
PHILLIPS	89	HPW
HAINES	86	IMB
PARK	85	IMB

 $\tau(p \rightarrow \mu^+ e^+ e^-)$ 

LIMIT ( $10^{30}$ years)	PARTICLE	CL%	EVTS	BKGD EST
>529	p	90	0	1.0

DOCUMENT ID	TECN
MCGREW	99

• • • We do not use the following data for averages, fits, limits, etc. • • •

> 91	p	90	0	$\leq 0.1$
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BERGER	91	FREJ
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 $\tau(p \rightarrow \mu^+ \mu^+ \mu^-)$ 

LIMIT ( $10^{30}$ years)	PARTICLE	CL%	EVTS	BKGD EST
>675	p	90	0	0.3

DOCUMENT ID	TECN
MCGREW	99

• • • We do not use the following data for averages, fits, limits, etc. • • •

>119	p	90	0	0.2
> 10.5	p	90	0	0.7
>190	p	90	1	0.1
> 44	p (free)	90	1	0.7
>190	p	90	1	0.9
> 2.1	p	90	1	

66 BATTISTONI 82 NUSX

66 We have converted 1 possible event to 90% CL limit.

T54

NODE=S016T17  
NODE=S016T17

 $\tau(p \rightarrow \mu^+ \nu \nu)$ 

LIMIT ( $10^{30}$ years)	PARTICLE	CL%	EVTS	BKGD EST
>21	p	90	7	11.23

DOCUMENT ID	TECN
BERGER	91B

T55

NODE=S016T56  
NODE=S016T56

 $\tau(p \rightarrow e^- \mu^+ \mu^+)$ 

LIMIT ( $10^{30}$ years)	PARTICLE	CL%	EVTS	BKGD EST
>6.0	p	90	0	0.7

DOCUMENT ID	TECN
PHILLIPS	89

T56

NODE=S016T36  
NODE=S016T36

 $\tau(n \rightarrow 3\nu)$ 

T57

See also the "to anything" and "disappearance" limits for bound nucleons in the "p Mean Life" data block just in front of the list of possible p decay modes. Such modes could of course be to three (or five) neutrinos, and the limits are stronger, but we do not repeat them here.

LIMIT ( $10^{30}$ years)	PARTICLE	CL%	EVTS	BKGD EST
>0.00049	n	90	2	2

DOCUMENT ID	TECN
67 SUZUKI	93B

• • • We do not use the following data for averages, fits, limits, etc. • • •

>0.0023	n	90		
>0.00003	n	90	11	6.1
>0.00012	n	90	7	11.2
>0.0005	n	90	0	

68 GLICENSTEIN	97	KAMI
69 BERGER	91B	FREJ
69 BERGER	91B	FREJ
LEARNED	79	RVUE

67 The SUZUKI 93B limit applies to any of  $\nu_e \nu_e \bar{\nu}_e$ ,  $\nu_\mu \nu_\mu \bar{\nu}_\mu$ , or  $\nu_\tau \nu_\tau \bar{\nu}_\tau$ .

68 GLICENSTEIN 97 uses Kamioka data and the idea that the disappearance of the neutron's magnetic moment should produce radiation.

69 The first BERGER 91B limit is for  $n \rightarrow \nu_e \nu_e \bar{\nu}_e$ , the second is for  $n \rightarrow \nu_\mu \nu_\mu \bar{\nu}_\mu$ .

NODE=S016T21

OCCUR=2  
NODE=S016T21;LINKAGE=B  
NODE=S016T21;LINKAGE=C

NODE=S016T21;LINKAGE=A

NODE=S016T73

NODE=S016T73  
NODE=S016T73

 $\tau(n \rightarrow 5\nu)$ 

T58

See the note on  $\tau(n \rightarrow 3\nu)$  on the previous data block.

LIMIT ( $10^{30}$ years)	PARTICLE	CL%	EVTS	BKGD EST
>0.0017	n	90		

DOCUMENT ID	TECN
70 GLICENSTEIN	97

• • • We do not use the following data for averages, fits, limits, etc. • • •

>0.0017 n 90 70 GLICENSTEIN 97 KAMI

70 GLICENSTEIN 97 uses Kamioka data and the idea that the disappearance of the neutron's magnetic moment should produce radiation.

NODE=S016T73;LINKAGE=C

**Inclusive modes** **$\tau(N \rightarrow e^+ \text{ anything})$** 

LIMIT ( $10^{30}$ years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID	TECN
>0.6	p, n	90			71 LEARNED	RVUE

71 The electron may be primary or secondary.

**T59**

NODE=S016335

 **$\tau(N \rightarrow \mu^+ \text{ anything})$** 

LIMIT ( $10^{30}$ years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID	TECN
>12	p, n	90	2		72,73 CHERRY	HOME

• • • We do not use the following data for averages, fits, limits, etc. • • •

> 1.8	p, n	90			73 COWSIK	CNTR
> 6	p, n	90			73 LEARNED	RVUE

72 We have converted 2 possible events to 90% CL limit.

73 The muon may be primary or secondary.

**T60**

NODE=S016T01;LINKAGE=D

 **$\tau(N \rightarrow \nu \text{ anything})$** 

Anything = $\pi$ , $\rho$ , $K$ , etc.						
LIMIT ( $10^{30}$ years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID	TECN
>0.0002	p, n	90	0		LEARNED	RVUE

 **$\tau(N \rightarrow e^+ \pi^0 \text{ anything})$** 

LIMIT ( $10^{30}$ years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID	TECN
>0.6	p, n	90	0		LEARNED	RVUE

 **$\tau(N \rightarrow 2 \text{ bodies}, \nu\text{-free})$** 

LIMIT ( $10^{30}$ years)	PARTICLE	CL%	EVTS	BKGD EST	DOCUMENT ID	TECN
>1.3	p, n	90	0		ALEKSEEV	BAKS

**T62**

NODE=S016T19;LINKAGE=C

 **$\Delta B = 2 \text{ dinucleon modes}$** 

LIMIT ( $10^{30}$ years)	CL%	EVTS	BKGD EST	DOCUMENT ID	TECN	COMMENT
>0.7	90	4	2.34	BERGER	91B FREJ	$\tau$ per iron nucleus

**T64**

NODE=S016T62;LINKAGE=C

 **$\tau(pn \rightarrow \pi^+ \pi^0)$** 

LIMIT ( $10^{30}$ years)	CL%	EVTS	BKGD EST	DOCUMENT ID	TECN	COMMENT
>2.0	90	0	0.31	BERGER	91B FREJ	$\tau$ per iron nucleus

**T65**

NODE=S016T63;LINKAGE=C

 **$\tau(nn \rightarrow \pi^+ \pi^-)$** 

LIMIT ( $10^{30}$ years)	CL%	EVTS	BKGD EST	DOCUMENT ID	TECN	COMMENT
>0.7	90	4	2.18	BERGER	91B FREJ	$\tau$ per iron nucleus

**T66**

NODE=S016T64;LINKAGE=C

 **$\tau(nn \rightarrow \pi^0 \pi^0)$** 

LIMIT ( $10^{30}$ years)	CL%	EVTS	BKGD EST	DOCUMENT ID	TECN	COMMENT
>3.4	90	0	0.78	BERGER	91B FREJ	$\tau$ per iron nucleus

**T67**

NODE=S016T65;LINKAGE=C

 **$\tau(pp \rightarrow e^+ e^+)$** 

LIMIT ( $10^{30}$ years)	CL%	EVTS	BKGD EST	DOCUMENT ID	TECN	COMMENT
>5.8	90	0	<0.1	BERGER	91B FREJ	$\tau$ per iron nucleus

**T68**

NODE=S016T66;LINKAGE=C

 **$\tau(pp \rightarrow e^+ \mu^+)$** 

LIMIT ( $10^{30}$ years)	CL%	EVTS	BKGD EST	DOCUMENT ID	TECN	COMMENT
>3.6	90	0	<0.1	BERGER	91B FREJ	$\tau$ per iron nucleus

**T69**

NODE=S016T67;LINKAGE=C

$\tau(pp \rightarrow \mu^+ \mu^+)$ 

LIMIT ( $10^{30}$ years)	CL%	EVTS	BKGD EST
>1.7	90	0	0.62

DOCUMENT ID	TECN	COMMENT
BERGER	91B FREJ	$\tau$ per iron nucleus

**T70**NODE=S016T68  
NODE=S016T68 $\tau(pn \rightarrow e^+ \bar{\nu})$ 

LIMIT ( $10^{30}$ years)	CL%	EVTS	BKGD EST
>2.8	90	5	9.67

DOCUMENT ID	TECN	COMMENT
BERGER	91B FREJ	$\tau$ per iron nucleus

**T71**NODE=S016T69  
NODE=S016T69 $\tau(pn \rightarrow \mu^+ \bar{\nu})$ 

LIMIT ( $10^{30}$ years)	CL%	EVTS	BKGD EST
>1.6	90	4	4.37

DOCUMENT ID	TECN	COMMENT
BERGER	91B FREJ	$\tau$ per iron nucleus

**T72**NODE=S016T70  
NODE=S016T70 $\tau(nn \rightarrow \nu_e \bar{\nu}_e)$ 

We include "invisible" modes here.

LIMIT ( $10^{30}$ years)	CL%	EVTS	BKGD EST
>1.4	90		

DOCUMENT ID	TECN	COMMENT
74 ARAKI	06 KLND	$nn \rightarrow$ invisible

• • • We do not use the following data for averages, fits, limits, etc. • • •

>0.000042 90	75 TRETYAK	04 CNTR	$nn \rightarrow$ invisible
>0.000049 90	76 BACK	03 BORX	$nn \rightarrow$ invisible
>0.000012 90	77 BERNABEI	00B DAMA	$nn \rightarrow$ invisible
>0.000012 90	BERGER	91B FREJ	$\tau$ per iron nucleus

74 ARAKI 06 looks for signs of de-excitation of the residual nucleus after disappearance of two neutrons from the  $s$  shell of  $^{12}\text{C}$ .75 TRETYAK 04 uses data from an old Homestake-mine radiochemical experiment on limits for invisible decays of  $^{39}\text{K}$  to  $^{37}\text{Ar}$ .76 BACK 03 looks for decays of unstable nuclides left after  $NN$  decays of parent  $^{12}\text{C}$ ,  $^{13}\text{C}$ ,  $^{16}\text{O}$  nuclei. These are "invisible channel" limits.77 BERNABEI 00B looks for the decay of a  $^{127}\text{Xe}$  nucleus following the disappearance of an  $nn$  pair in the otherwise-stable  $^{129}\text{Xe}$  nucleus. The limit here applies as well to  $nn \rightarrow \nu_\mu \bar{\nu}_\mu$ ,  $nn \rightarrow \nu_\tau \bar{\nu}_\tau$ , or any "disappearance" mode.**T73**NODE=S016T71  
NODE=S016T71  
NODE=S016T71 $\tau(nn \rightarrow \nu_\mu \bar{\nu}_\mu)$ 

See the proceeding data block. "Invisible modes" would include any multi-neutrino mode.

LIMIT ( $10^{30}$ years)	CL%	EVTS	BKGD EST	CL%
>1.4	(CL = 90%) OUR LIMIT			

DOCUMENT ID	TECN	COMMENT
74 ARAKI	06 KLND	$nn \rightarrow$ invisible

• • • We do not use the following data for averages, fits, limits, etc. • • •

>0.000006 90	4 4.4	BERGER	91B FREJ	$\tau$ per iron nucleus
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**T74**NODE=S016T72  
NODE=S016T72  
NODE=S016T72

→ UNCHECKED ←

 $\tau(pn \rightarrow \text{invisible})$ 

This violates charge conservation as well as baryon number conservation.

VALUE ( $10^{30}$ years)	CL%	DOCUMENT ID	TECN
>0.000021	90	78 TRETYAK	04 CNTR

DOCUMENT ID	TECN	COMMENT
78 TRETYAK	04 CNTR	

NODE=S016T77  
NODE=S016T77  
NODE=S016T77

NODE=S016T77;LINKAGE=TR

78 TRETYAK 04 uses data from an old Homestake-mine radiochemical experiment on limits for invisible decays of  $^{39}\text{K}$  to  $^{37}\text{Ar}$ . $\tau(pp \rightarrow \text{invisible})$ 

This violates charge conservation as well as baryon number conservation.

LIMIT ( $10^{30}$ years)	CL%	EVTS	BKGD EST	CL%
>0.00005	90	79 BACK	03 BORX	

DOCUMENT ID	TECN	COMMENT
79 BACK	03 BORX	

NODE=S016T76  
NODE=S016T76  
NODE=S016T76

NODE=S016T76;LINKAGE=BK

• • • We do not use the following data for averages, fits, limits, etc. • • •

>0.0000055 90	80 BERNABEI	00B DAMA
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79 BACK 03 looks for decays of unstable nuclides left after  $NN$  decays of parent  $^{12}\text{C}$ ,  $^{13}\text{C}$ ,  $^{16}\text{O}$  nuclei. These are "invisible channel" limits.80 BERNABEI 00B looks for the decay of a  $^{127}\text{Te}$  nucleus following the disappearance of a  $pp$  pair in the otherwise-stable  $^{129}\text{Xe}$  nucleus.

## $\bar{p}$ PARTIAL MEAN LIVES

The "partial mean life" limits tabulated here are the limits on  $\bar{\tau}/B_i$ , where  $\bar{\tau}$  is the total mean life for the antiproton and  $B_i$  is the branching fraction for the mode in question.

### $\tau(\bar{p} \rightarrow e^- \gamma)$

VALUE (years)	CL%	DOCUMENT ID	TECN	COMMENT	77
$> 7 \times 10^5$	90	GEER 00	APEX	8.9 GeV/c $\bar{p}$ beam	
$\bullet \bullet \bullet$ We do not use the following data for averages, fits, limits, etc. $\bullet \bullet \bullet$					
>1848	95	GEER 94	CALO	8.9 GeV/c $\bar{p}$ beam	

NODE=S016TB1  
NODE=S016TB1

### $\tau(\bar{p} \rightarrow \mu^- \gamma)$

VALUE (years)	CL%	DOCUMENT ID	TECN	COMMENT	78
$> 5 \times 10^4$	90	GEER 00	APEX	8.9 GeV/c $\bar{p}$ beam	
$\bullet \bullet \bullet$ We do not use the following data for averages, fits, limits, etc. $\bullet \bullet \bullet$					
$> 5.0 \times 10^4$	90	HU 98B	APEX	8.9 GeV/c $\bar{p}$ beam	

NODE=S016TB6  
NODE=S016TB6

### $\tau(\bar{p} \rightarrow e^- \pi^0)$

VALUE (years)	CL%	DOCUMENT ID	TECN	COMMENT	79
$> 4 \times 10^5$	90	GEER 00	APEX	8.9 GeV/c $\bar{p}$ beam	
$\bullet \bullet \bullet$ We do not use the following data for averages, fits, limits, etc. $\bullet \bullet \bullet$					
>554	95	GEER 94	CALO	8.9 GeV/c $\bar{p}$ beam	

NODE=S016TB2  
NODE=S016TB2

### $\tau(\bar{p} \rightarrow \mu^- \pi^0)$

VALUE (years)	CL%	DOCUMENT ID	TECN	COMMENT	780
$> 5 \times 10^4$	90	GEER 00	APEX	8.9 GeV/c $\bar{p}$ beam	
$\bullet \bullet \bullet$ We do not use the following data for averages, fits, limits, etc. $\bullet \bullet \bullet$					
$> 4.8 \times 10^4$	90	HU 98B	APEX	8.9 GeV/c $\bar{p}$ beam	

NODE=S016TB7  
NODE=S016TB7

### $\tau(\bar{p} \rightarrow e^- \eta)$

VALUE (years)	CL%	DOCUMENT ID	TECN	COMMENT	781
$> 2 \times 10^4$	90	GEER 00	APEX	8.9 GeV/c $\bar{p}$ beam	
$\bullet \bullet \bullet$ We do not use the following data for averages, fits, limits, etc. $\bullet \bullet \bullet$					
>171	95	GEER 94	CALO	8.9 GeV/c $\bar{p}$ beam	

NODE=S016TB3  
NODE=S016TB3

### $\tau(\bar{p} \rightarrow \mu^- \eta)$

VALUE (years)	CL%	DOCUMENT ID	TECN	COMMENT	782
$> 8 \times 10^3$	90	GEER 00	APEX	8.9 GeV/c $\bar{p}$ beam	
$\bullet \bullet \bullet$ We do not use the following data for averages, fits, limits, etc. $\bullet \bullet \bullet$					
$> 7.9 \times 10^3$	90	HU 98B	APEX	8.9 GeV/c $\bar{p}$ beam	

NODE=S016TB8  
NODE=S016TB8

### $\tau(\bar{p} \rightarrow e^- K_S^0)$

VALUE (years)	CL%	DOCUMENT ID	TECN	COMMENT	783
$> 900$	90	GEER 00	APEX	8.9 GeV/c $\bar{p}$ beam	
$\bullet \bullet \bullet$ We do not use the following data for averages, fits, limits, etc. $\bullet \bullet \bullet$					
> 29	95	GEER 94	CALO	8.9 GeV/c $\bar{p}$ beam	

NODE=S016TB4  
NODE=S016TB4

### $\tau(\bar{p} \rightarrow \mu^- K_S^0)$

VALUE (years)	CL%	DOCUMENT ID	TECN	COMMENT	784
$> 4 \times 10^3$	90	GEER 00	APEX	8.9 GeV/c $\bar{p}$ beam	
$\bullet \bullet \bullet$ We do not use the following data for averages, fits, limits, etc. $\bullet \bullet \bullet$					
$> 4.3 \times 10^3$	90	HU 98B	APEX	8.9 GeV/c $\bar{p}$ beam	

NODE=S016TB9  
NODE=S016TB9

### $\tau(\bar{p} \rightarrow e^- K_L^0)$

VALUE (years)	CL%	DOCUMENT ID	TECN	COMMENT	785
$> 9 \times 10^3$	90	GEER 00	APEX	8.9 GeV/c $\bar{p}$ beam	
$\bullet \bullet \bullet$ We do not use the following data for averages, fits, limits, etc. $\bullet \bullet \bullet$					
>9	95	GEER 94	CALO	8.9 GeV/c $\bar{p}$ beam	

NODE=S016TB5  
NODE=S016TB5

### $\tau(\bar{p} \rightarrow \mu^- K_L^0)$

VALUE (years)	CL%	DOCUMENT ID	TECN	COMMENT	786
$> 7 \times 10^3$	90	GEER 00	APEX	8.9 GeV/c $\bar{p}$ beam	
$\bullet \bullet \bullet$ We do not use the following data for averages, fits, limits, etc. $\bullet \bullet \bullet$					
$> 6.5 \times 10^3$	90	HU 98B	APEX	8.9 GeV/c $\bar{p}$ beam	

NODE=S016TC1  
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$\tau(\bar{p} \rightarrow e^- \gamma\gamma)$ 

<u>VALUE</u> (years)	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	<b>T87</b>
$>2 \times 10^4$	90	GEER	00	APEX	8.9 GeV/c $\bar{p}$ beam

 $\tau(\bar{p} \rightarrow \mu^- \gamma\gamma)$ 

<u>VALUE</u> (years)	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	<b>T88</b>
$>2 \times 10^4$	90	GEER	00	APEX	8.9 GeV/c $\bar{p}$ beam

• • • We do not use the following data for averages, fits, limits, etc. • • •

$>2.3 \times 10^4$	90	HU	98B	APEX	8.9 GeV/c $\bar{p}$ beam
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 $\tau(\bar{p} \rightarrow e^- \rho)$ 

<u>VALUE</u> (years)	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	<b>T89</b>
• • • We do not use the following data for averages, fits, limits, etc. • • •					

>200	90	81 GEER	00	APEX	8.9 GeV/c $\bar{p}$ beam
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81 This GEER 00 measurement has been withdrawn; see GEER 00C.

 $\tau(\bar{p} \rightarrow e^- \omega)$ 

<u>VALUE</u> (years)	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	<b>T90</b>
>200	90	GEER	00	APEX	8.9 GeV/c $\bar{p}$ beam

 $\tau(\bar{p} \rightarrow e^- K^*(892)^0)$ 

<u>VALUE</u> (years)	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	<b>T91</b>
• • • We do not use the following data for averages, fits, limits, etc. • • •					

>1 $\times 10^3$	90	82 GEER	00	APEX	8.9 GeV/c $\bar{p}$ beam
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82 This GEER 00 measurement has been withdrawn; see GEER 00C.

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DIX	70	Thesis Case	F.W. Dix	(CASE)	REFID=11649
HARRISON	69	PRL 22 1263	G.E. Harrison, P.G.H. Sandars, S.J. Wright	(OXF)	REFID=11650
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